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PIPE LINE INDUSTRY

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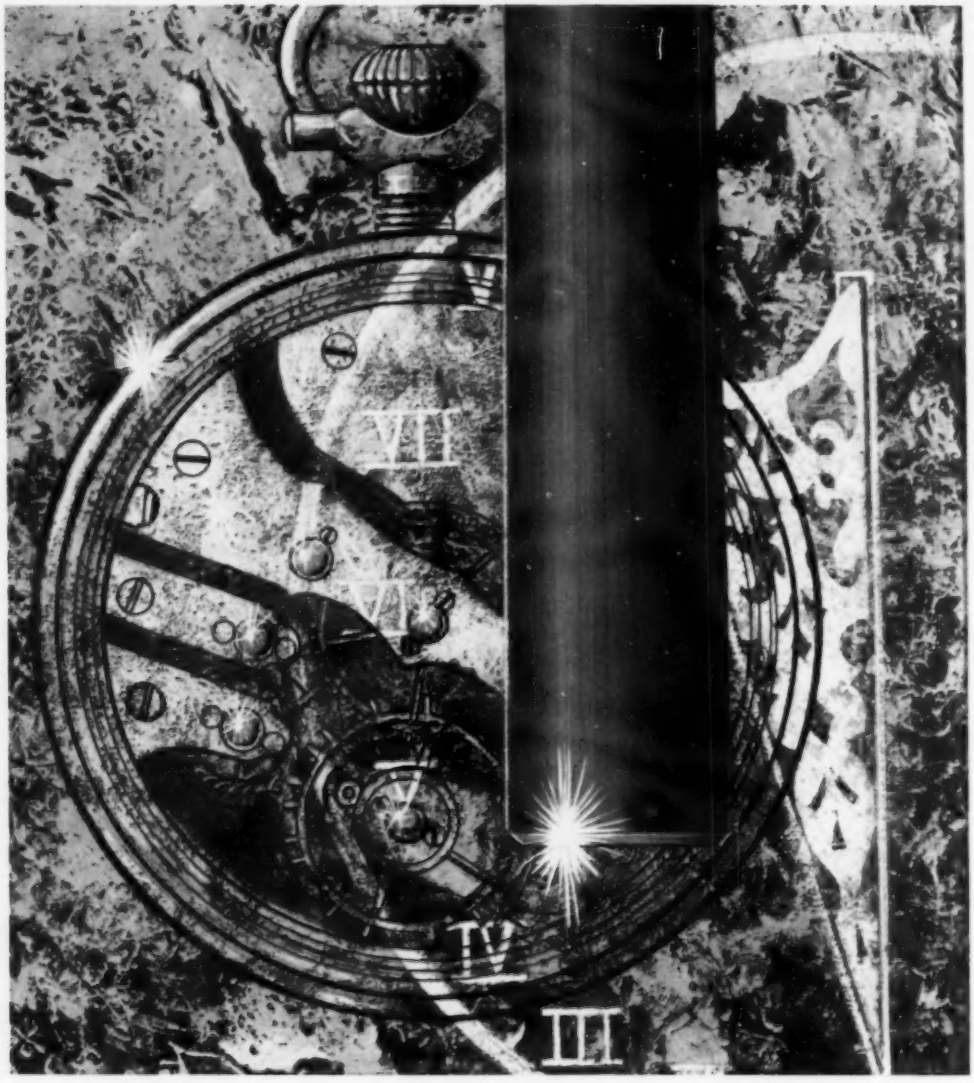

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PIPE LINE INDUSTRY

A GULF PUBLISHING COMPANY PUBLICATION

June 1961 Vol. 14, No. 6

CONTENTS and Quick Look

To help you put first things first, scan these time-saving digests, checking ☑ those you want to read first.

AGA TRANSMISSION REPORT

Report on Gas Storage in 19 Aquifers

☐ By moving gas fields into the large market areas, gas companies have been saving fantastic amounts of money in pipe line facilities. The newest wrinkle in this regard is storing gas in underground water sands and limestones. The idea is successful and the practice is growing by leaps and bounds. Here is a report from all of the companies engaged in this type operation.

By E. Vincent Martinson.....Page 38

How to Make Gas Leakage Surveys For Only $5 Per Mile

☐ An infrared analyzer, mounted in a pickup truck has cut the cost of leakage surveys 90 percent for Southern California Gas Company. The instrument can detect 5 parts of methane per million parts of air; and with probes sniffing near the surface of the ground, the two-man leakage crew has found all major leaks along the route surveyed.

By P. S. Magruder, Jr.....Page 43

How Weather Affects Dispatching in Southern Alberta

☐ Few places on earth have such sudden changes in temperature. Cold winds from the Yukon can send the thermometer below zero in just a few hours; a Chinook wind from the Pacific can bounce it back up at the rate of six degrees per hour. One idea worth copying—these pipeliners are installing aluminum and steel rural electrification conductor for telephone wires. They have had no breakage since they started this practice.

By G. D. Kellam.....Page 46

Engineering Aspects of Photogrammetry

☐ Some engineers are unaware of the great value and excellent engineering capabilities of photogrammetry. Here is an explanation of its basic principles which not only make it easy to understand, but also make it easier to trust.

By B. Austin Barry.....Page 49

Trunkline Reports on Low-Cost Sandblasting That Increases Gas Flow (Part 2)

☐ Last month's PIPE LINE INDUSTRY described this new technique and gave the results of tests on a 4-inch section of pipe. This second part of the article gives results of tests on large diameter pipe and points out what pipeliners can expect in the future from this form of system improvement.

By Adrain W. McAnneny and Lester C. Sullivan.Page 54

How to Use New Plastic Grout

☐ Main advantages of this new premium quality material are high compressive, tensile and bond strengths, good flexural and vibration resisting properties, plus a high resistance to water absorption or oil deterioration. They cost more but are being specified on many additions because of many offsetting advantages.

By Robert L. Rowan, Jr.....Page 61

Trunkline Solves Vibration Problem

☐ For years, the gas industry has lived with the problem of restraining vibrations in suction and discharge piping to compressor cylinders. Most of the trouble has come from the suction piping which required elevation changes to gain entrance to the cylinders from the top side. Trunkline engineers have eliminated the need for elevation changes; both suction and discharge piping enters the cylinders from the underside. Both bottles lie in the same plane and vibration has been virtually eliminated.

By Lester C. Sullivan.....Page 65

Midget Meters Keep Tab On Each Drop of Oil

☐ On compressor engine and cylinders, these minute positive displacement meters that can measure oil by the drop or by the gallon are proving highly effective in Natural Gas Pipeline's stations. They have cut down on engine trouble and maintenance, and at the same time, have reduced oil consumption. They may become a must for automation.....Page 68

API Technology School Completes Tenth Term

☐ Pipeliners with much practical experience, little theory or those with theory but little experience, have gotten much out of the API Division of Transportation-University of Texas co-sponsored School of Pipe Line Technology. Instructors are industry experts who devote time to the six-week course held semi-annually for crude oil or product pipeliners.

By Donald G. DePugh.....Page 69

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Automation for Pipe Lines by Evolution

THERE HAS BEEN MUCH said and written on the subject of automation of pipe lines in recent months, and there will undoubtedly be much more. Industry associations have spotlighted this subject at two spring meetings. The Petroleum Industry Electric Association and the American Gas Association have both become active in this field.

N. B. LauBach

At the AGA Operating Section Conference in Denver, Neal B. LauBach, Colorado Interstate Gas Co. Vice-President and Chairman of the AGA's Automation Committee, made a number of good points worth pondering.

Here are some of the highlights of his remarks.

". . . **Control of production through automatic devices reduces or eliminates the machine-like operations of human labor and places the individual in a position superior to the machine. . . .**

". . . If we look at our pipe line operations today, we realize we have a considerable degree of automatic operation . . . Even though much development has already occurred and more is in progress we seem to have a feeling of uncertainty as to how this problem of automation should be handled . . . **Experience of industry varies from disappointment to enthusiasm. This situation has tended to create an area of misunderstanding between management on the one hand, and the engineering and operations groups on the other. Efforts now being organized through the AGA Automation Committee should clarify and improve this situation.**

". . . Let us look at a few of the problems. In the first place, it is not necessary or desirable to consider total automatic operation of a pipe line system in order to enjoy the advantages of automation. One of the fundamental advantages of automation is that it can be applied to isolated and individual operating functions which are substantially complete and can be made self regulating within the isolated unit. . . .

". . . **Without too much difficulty, these independent systems, both old and new, may be integrated into a higher degree of automation without loss of the initial investment. It must be understood that each individual pipe line system presents a different problem, and that each design and application of automation becomes a unique problem for the designer.**

Personnel Considerations. ". . . **Automation is much more than a mechanical problem since it involves organization and utilization of labor. Many manual jobs can be eliminated, while creating new jobs.** The maintenance of automation equipment requires a higher degree of skill than needed for some of the equipment with which our employes are familiar. A training program to upgrade potentially qualified personnel, therefore, becomes a part of the automation program.

". . . **The managements of the gas industry have shown their ability to meet the continually changing requirements of organization and personnel.** Automation can be programed to effect its ultimate objectives in an evolutionary rather than a revolutionary manner.

Coordination Between Operations and Engineering ". . . **If an automation system is too complex to be understood and maintained by ordinary people, it probably will be a disappointment.** It is almost a truism in operations that "almost anything works if the operator wants it to work." My advice is, "open the door early and keep it open between operations and engineering." . . .

Supplier-Purchaser Understanding. ". . . Advanced automation equipment must be custom tailored to the individual requirements. Standardization of hardware does not appear to be a possibility at this time. The knowledge required to design automatic equipment is the property of the equipment manufacturer, while the knowledge of functions to be performed and manner of performance is the property of the gas company. Because of this situation, **we find great need for improved communications in the supplier-purchaser relationship.**

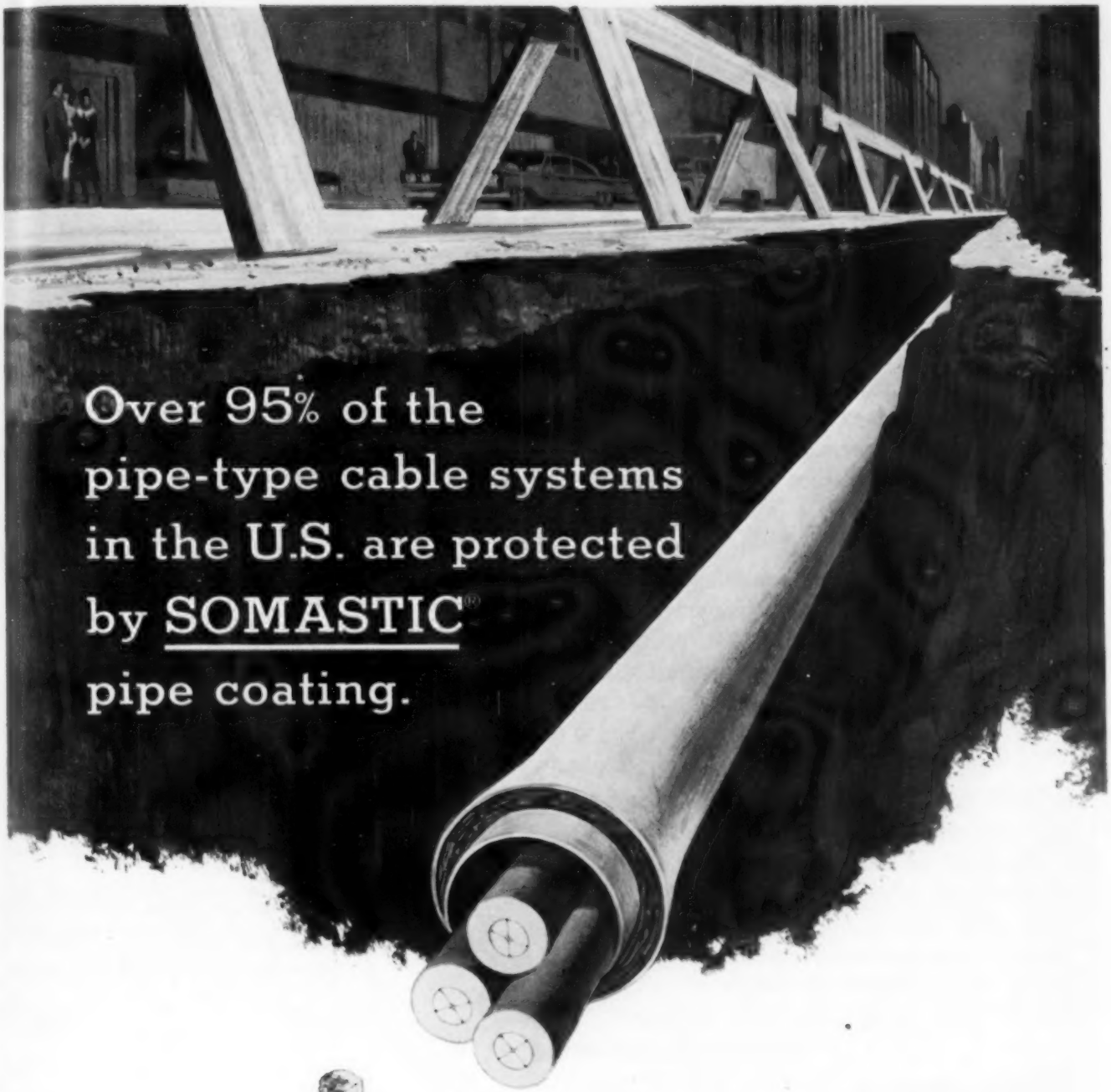
". . . For a better understanding of the uses and limitations of automation, it is imperative that a greater number of gas company personnel become familiar with computer logic and procedure. Minimum knowledge of the subject can be acquired by people of average mentality and education. . . . On-the-job experience is not only practical, but the most economical method of becoming acquainted with the world of automation.

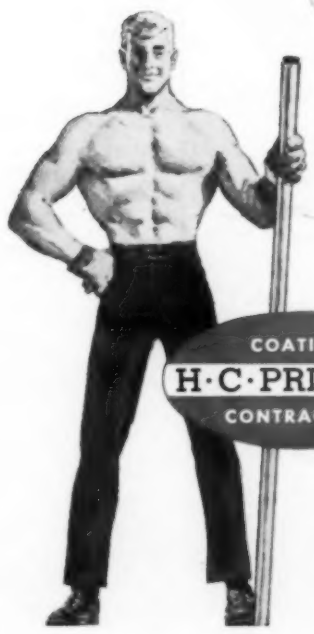
Economics ". . . **The matter of economics must, of course, be met.** . . . Methods can be roughly grouped into two categories. First, absolute proof based on historical cost records and known reductions in costs to follow the installation of equipment; and second, use of intangible costs and cost reductions supported by considered judgment and opinion. In the case of new developments and unproven equipment, such as automation, it would seem advisable to use both methods in an effort to establish the parameters of risk and benefit.

". . . In the field of automation proper attention should be given to intangible benefits, . . . and that the fruits of imagination receive proper consideration. . . .

". . . On the other hand, the application of automation to existing facilities cannot be so easily justified nor can it be so easily designed, but the complexity of the problem is not an economic justification for abandoning its consideration. . . ."

Editor's Note: These thoughts of AGA's Automation Committee Chairman are worth studying.





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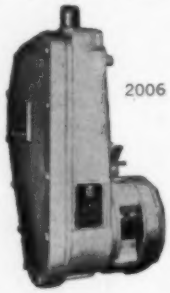
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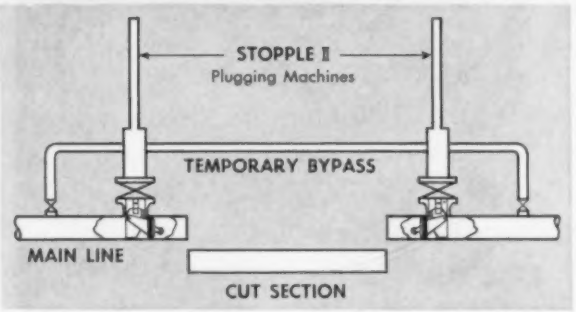

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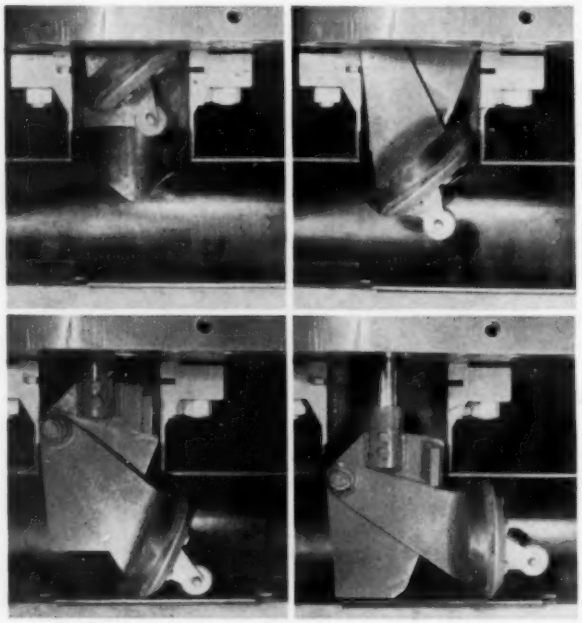

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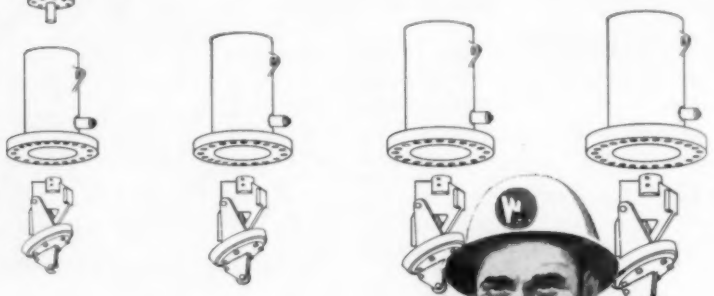

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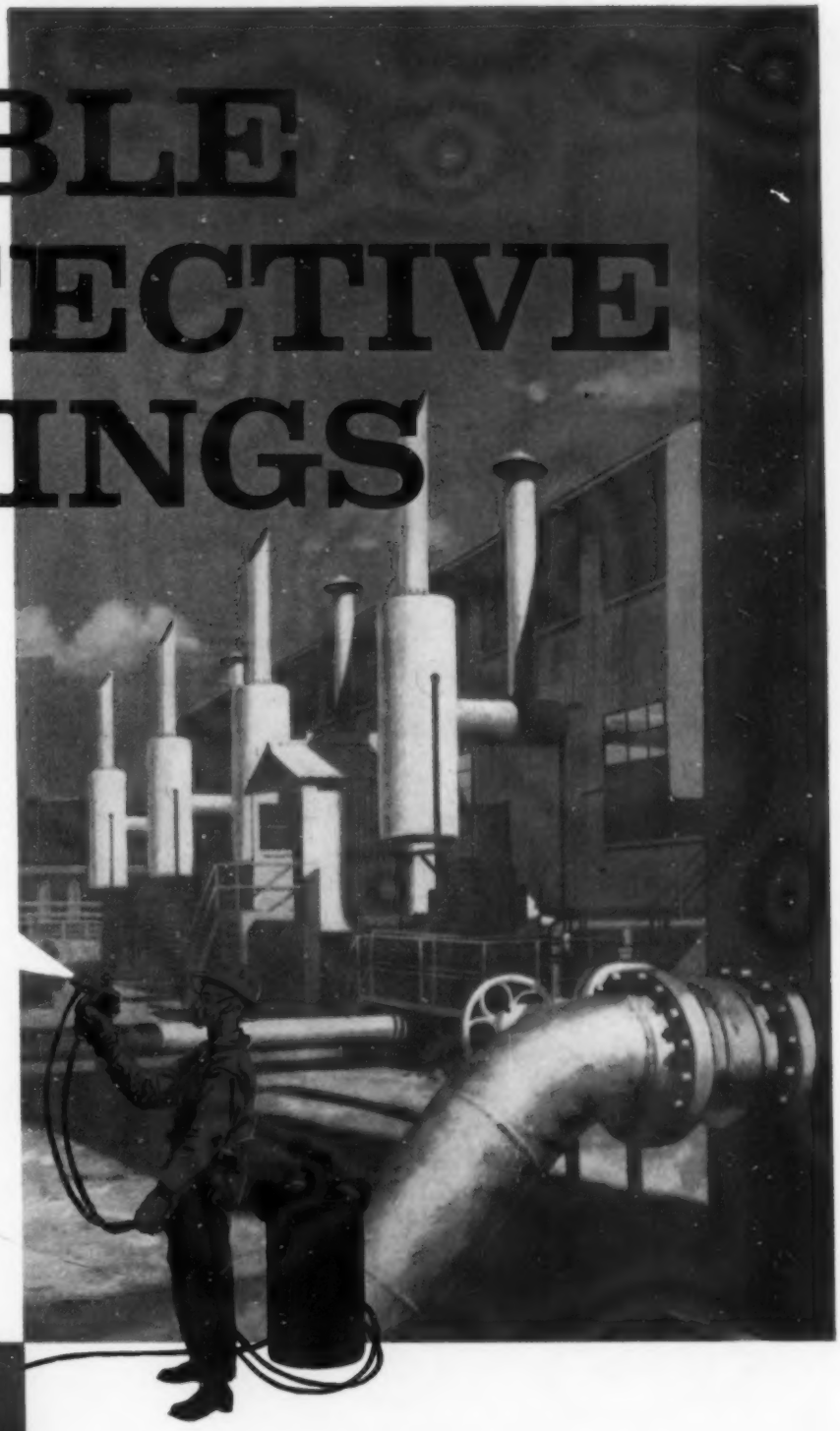

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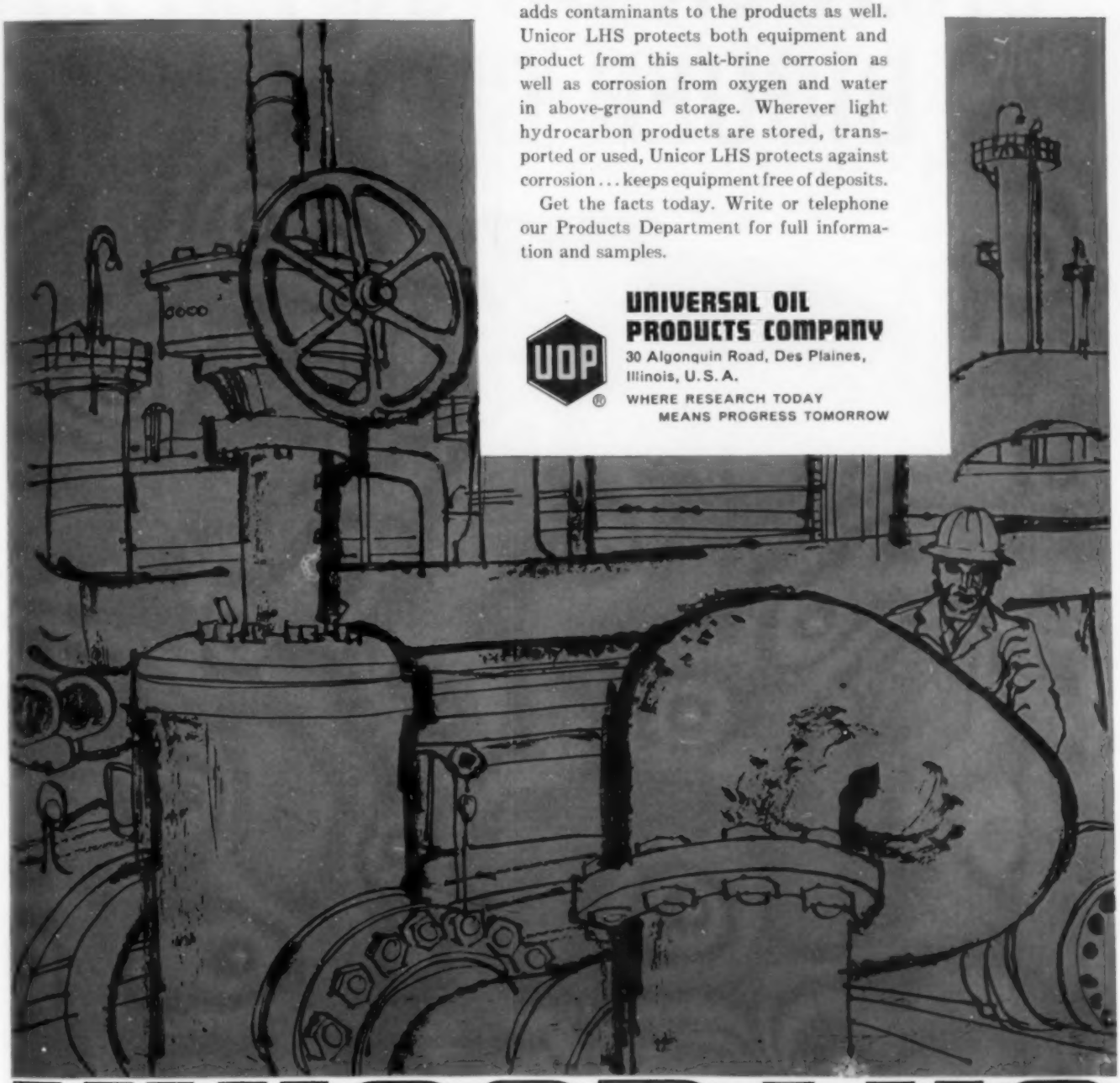

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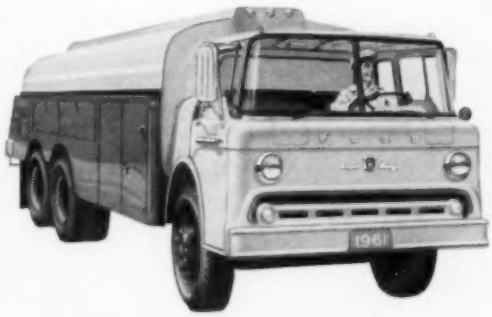

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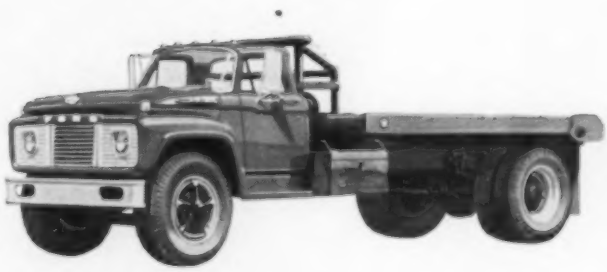

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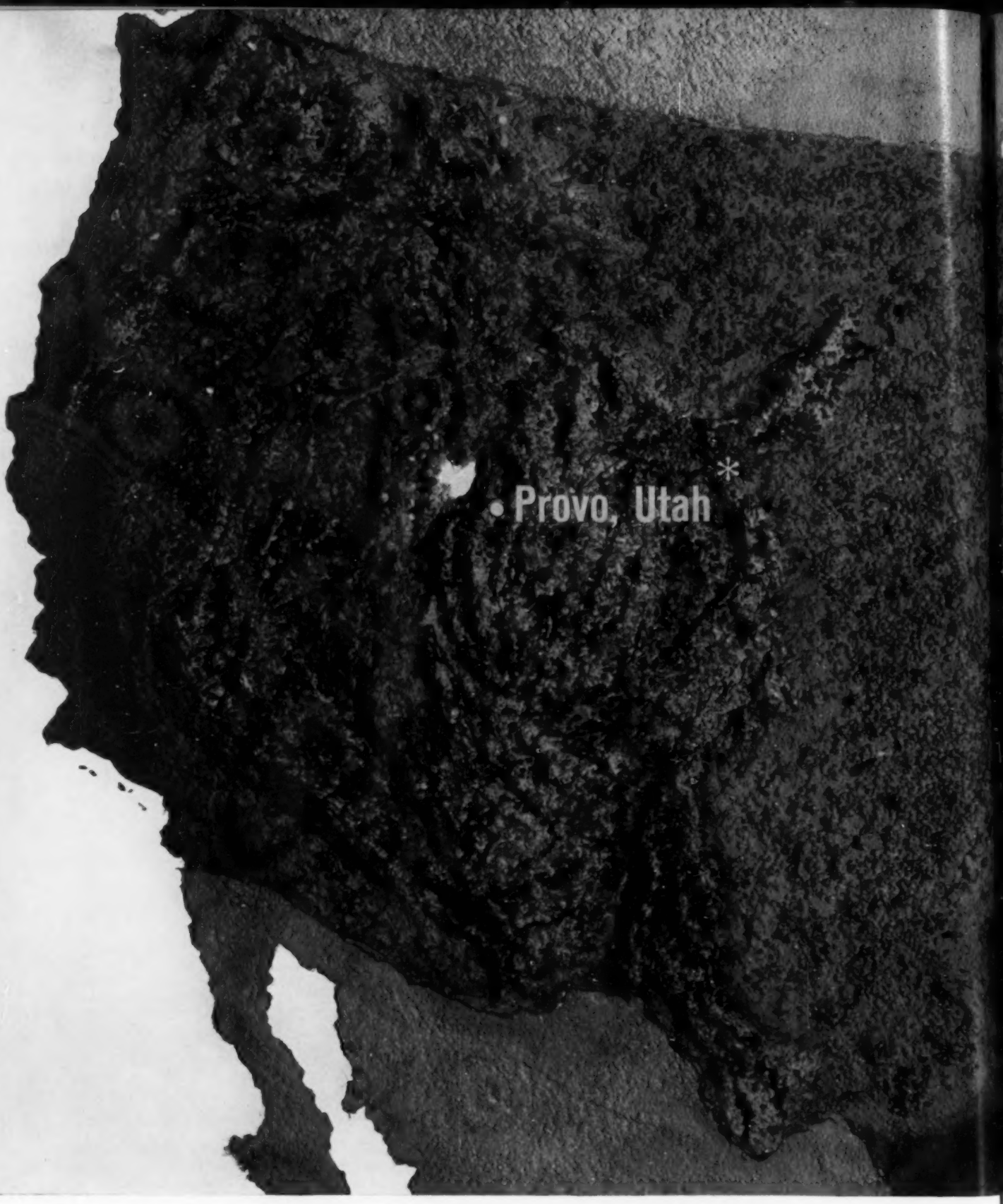

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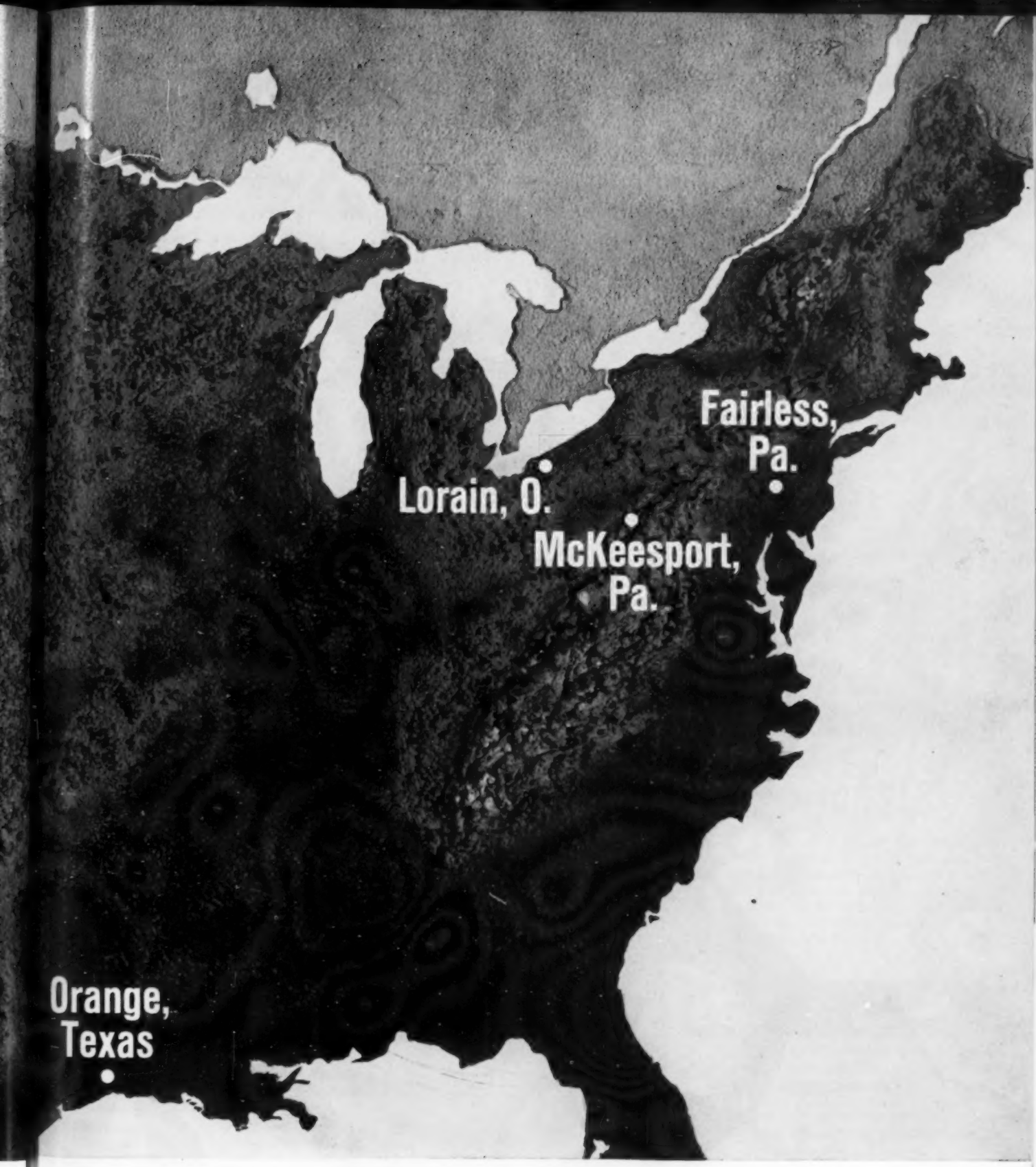

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Asbestos Pipe Wrap Our Product

Nicolet Asbestos Pipe Wraps and **"Old Nic" Glass Wrap** are the modern armor for today's pipe lines.

Your pipe line requirements can be completely met with either #15 "Standard", #8 "Tufbestos" or #10 "Reflecto" (the new, white, improved Asbestos Felt). Together with "Old Nic" Glass Wrap, you have absolute assurance of getting the finest and most complete line of pipe line protection products obtainable anywhere.

Write today for full specifications and samples of Nicolet pipe protection products.

Distributed throughout the United States

NICOLET INDUSTRIES, INC.

FLORHAM PARK, NEW JERSEY

BANTAM C-350 cleaning out ditch at road-crossing approach before lowering in 12" gas line.

handiest rig of all around pipeline jobs!

Here's the crane-excavator that's Johnny-on-the-spot anywhere it is needed, any time! The BANTAM C-350 crawler, for example, offers more trenching and excavating ability for its practical, permit-free size than ever before available.

This pipeliner's rig has all the needed features for this work—to speed up all kinds of jobs in the field or confined areas. BANTAM's low ground bearing pressure (less than 3 lbs. per sq. in. with 32" pads) with resulting high flotation means you work in the wettest going.

BANTAM's simplified mechanical controls deliver fast-action response and trouble-free performance year after year. With BANTAM you get such important extra benefits at **no** extra cost as 2-speed, independent travel for simultaneous lift, swing and travel . . . anti-friction bearings throughout . . . biggest brakes and clutches . . . more rugged design.

Dig 100′ of 5′ trench per hour, dig down to 18′10″ with the C-350 BANTAM's optional, long-boom back hoe. BANTAM sets you up to handle virtually any lifting, loading, excavating, erecting job with BANTAM's 11 fast-change attachments.

BANTAM T-350 cleaning out rock fragments and cutting ditch along paved street for 6" gas main. BANTAM has a size advantage in congested-area operations, yet is ideal for all field operations.

BANTAM T-350—most popular truck crane-excavator its size in America; preferred because of its rapid mobility and exceptional work speed and range. Big 11-ton lifting capacity; tools up for more pipeline jobs with 11 versatile attachments. Choice of five BANTAM-built carriers.

SCHIELD Bantam Co.

201 Park Street, Waverly, Iowa

World's largest producer of truck crane-excavators

PC-324

Please forward detailed BANTAM literature on:

- ☐ C-350 BANTAM crawler
- ☐ carrier-mounted T-350 BANTAM
- ☐ CR-350 BANTAM Self-Propelled
- ☐ new BANTAM Compact 250 5-ton, carrier-mounted shovel-crane

Name.....

Company.....

Address.....

City.....Zone....State.....

For more data on advertised products, use Readers' Service Cards, last page.

385 HP! FROM CATERPILLAR THE NEW D9G

MASSIVE HEAVY-DUTY UNDERCARRIAGE Immense strength and rigidity of undercarriage is one good solid reason why the D9G is more than equal to the roughest ripping job. Box section frame is wider and deeper than previous models. Hydraulic track adjusters are standard. Lifetime lubricated rollers with special alloy deep hardened rims assure long life . . . and they require no servicing until time to rebuild.

HIGH-PRODUCTION DOZER, PUSHER, RIPPER

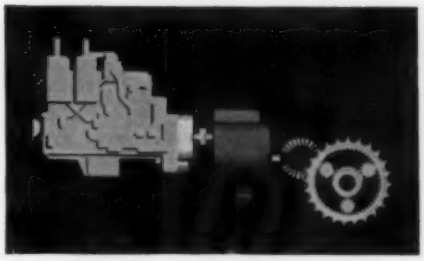
For high-volume dozing, pushloading or ripping, the new D9G has what it takes . . . at minimum cost per yard!

The engine in the new D9G delivers 385 flywheel horsepower. That's *100 more horsepower* than the first D9 introduced five years ago!

Weight is 64,800 pounds—14% more than the first D9!

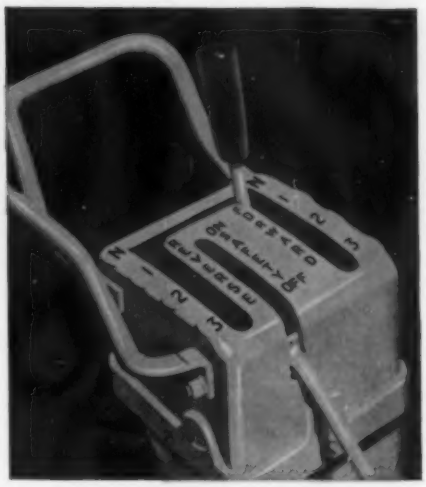
Torque divider power shift transmission . . . massive heavy-duty undercarriage . . . and power train with built-in ruggedness for long life.

What else is new? Matching the D9G is a full line of attachments—all designed to help this new tractor really put out on the toughest big jobs.



CAT D353 ENGINE AND MATCHED POWER TRAIN This engine, rated 385 HP (flywheel) at 1330 RPM, has been proven—and proven again—over thousands of hours on the roughest jobs. Its 6.25″ x 8″ six-cylinder design now incorporates *controlled turbocharging* and aftercooling (found only in the D9G among crawler tractors), assures more efficient use of fuel, increases maximum torque and provides fast engine response over a wide range of operation. Shroud-mounted fan reduces air recirculation; torque limiting clutch saves on fan horsepower. Plus: exclusive Caterpillar fuel injection system, twin dry-type air cleaners, oil-jet-cooled pistons, "Hi-Electro" hardened cylinder liners and crankshaft journals.

The new power train includes three major advances: *new oil-cooled steering clutches and brakes, new planetary final drives*, and a time and cost saving *common lube system*. The new spring-engaged, hydraulically-released steering clutches need no adjustments . . . have a proven longer service life. New, planetary final drives increase gear reduction ratios from 8.8:1 to 18:1, reducing torque load on all power train components. A common system cools and lubricates torque divider, transmission, bevel gear, steering clutches and brakes. This means one service point . . . one type of oil. The entire power train of the big new D9G has unitized construction for fast, individual removal of components.



PROVEN TORQUE DIVIDER POWER SHIFT This exclusive Caterpillar design feature—standard equipment on the D9G—combines the efficiency and snap of direct drive with the load-matching and anti-stall characteristics of torque converter. A single lever gives the operator finger-tip control of his machine. It adds up to fast cycle times and greater efficiency. You get more out of the machine *all day*.

A FULL LINE OF HIGH-PRODUCTION ATTACHMENTS New cable controls with larger clutch, brake and drum capacities—hydraulically boosted . . . new hydraulic controls in nine arrangements . . . special cushioned pushing equipment . . . angle, straight and U dozers, cable or hydraulic . . . rippers . . . scrapers . . . and others.

To prove the D9G's productive capabilities on your job, talk to your Caterpillar Dealer.

Caterpillar Tractor Co., General Offices, Peoria, Ill., U.S.A.

CATERPILLAR

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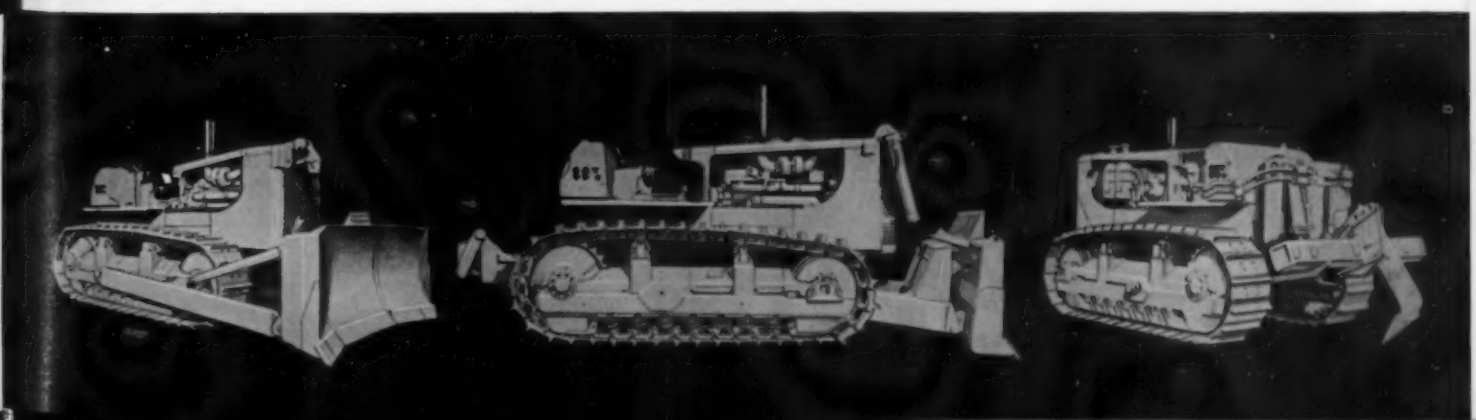
NEW D9G—BIG, POWERFUL, PRODUCTIVE



NEW ENGINEERED TEFLON PISTON RINGS

for Non-Lubricated Service

Garlock Teflon* Piston Rings may be used alone where piston is lightweight, vertically installed, or supported by tail rod (upper left). On large compressors and cylinders with heavy pistons, Teflon Rider Rings are recommended to support the piston (lower left).

Time after time, Teflon Piston and Rider Rings—the newest of Garlock products—prove effective in extending ring life under non-lubricated or chemical service.

A compressor used in wet hydrogen service was fitted with six rings of Teflon. Lubrication was eliminated and the rings were still in service after 2000 hours. Cast iron piston rings previously used needed lubrication and lasted less than 100 hours.

Another compressor operated at +350°F to supply instrument air. With Teflon Piston Rings, the compressor has been in continuous service for over 2500 hours without lubrication; the radial wear rate is approximately .009 per 1000 hours. Before this, the cylinder had to be lubricated; it was also necessary to periodically remove oil from the discharge air to prevent entry into instrument air lines.

The first really satisfactory piston rings for non-lubricated service, Garlock Teflon Piston and Rider Rings are engineered for longer life and better heat dissipation. They have the lowest coefficient of friction of all materials, ar chemically inert, and will not contaminate the gas or fluid in the system. Garlock Teflon Piston and Rider Rings will not crack or break, will not score cylinder walls, and are flexible for easy installation. They can be applied at temperatures from −420°F to +500°F, are available in carbon-graphite filled Teflon or glass-filled Teflon, and come in either butt joint, step joint, scarf cut or solid, depending on your needs.

Talk to your Garlock representative about Teflon Piston and Rider Rings. He is backed by years and years of experience in the design, manufacture and application of packings and seals of all types. You will find him in your locale at the nearest of the 26 Garlock sales offices throughout the U.S. and Canada. Or, write for Catalog AD-178. Garlock Inc., Palmyra, New York.

GARLOCK

Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket Company

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

*DuPont Trademark

When portable electric power is vital, you can't afford to gamble on "accident prone" parts. Only Onan offers so many safeguards against breakdown: Stellite valves, oversize bearings, shorter-stronger connecting rods and crankshafts. Equally important, *only* Onan is Performance Certified to deliver *all* the power promised by its nameplate.

Only Onan is certified to give you all the power promised by its nameplate

It's a fact that many electric plants on the market today do not deliver the output promised by their nameplate rating.

Every Onan plant is given a rugged workout *under full load* before it is shipped—*your assurance* that the Onan you buy is ready for hard work the day you get it.

But this isn't enough. Independent laboratory inspectors pull surprise inspections to double-check our tests and testing methods. They pull a plant off the line, run it, stop it, load it, overload it, check and recheck. Their torture test gives positive proof of Onan's quality. End result: *Onan's exclusive Performance Certification* . . . your assurance of getting every watt of power you pay for.

So when you're tempted by an electric plant "bargain," make sure its nameplate rating is not "inflated." Be sure you're getting full measure for your money. Remember, *the electric plant that short-changes you in power output is no bargain at any price!* Only Onan is Performance Certified to deliver everything the nameplate promises.

See Onan electric plants soon. Compare before you buy. You'll find your Onan distributor listed in the Yellow Pages. Call him or write direct.

PERFORMANCE CERTIFIED
We certify that when properly installed and operated this Onan electric plant will deliver the full power and the voltage and frequency regulation promised by its nameplate and published specifications. This plant has undergone several hours of running-in and testing under realistic load conditions, in accordance with procedures certified by an independent testing laboratory.
Onan
Onan

World's Leading Builder of Electric Power Plants

Onan

ONAN Division, Studebaker-Packard Corporation, 2697 University Ave. S. E., Minneapolis 14, Minn.

TEXANS SAY...

...it gets so hot in Texas that pipeliners just butt the pipe together and it welds itself. Or so they say.

The photo above was shot on a "cool" day in southwestern Texas. It was only 104°, not quite hot enough for "sun-welding." But the welders had the next best thing—easy-working Bethlehem electric resistance-weld pipe. It *always* takes a good weld. And it's made good and round, and with the proper bevel so that it will line up quickly.

ERW pipe in lengths up to 62 ft . . . sizes 5-9/16 to 16 in. OD

We make ERW line pipe in 62-ft lengths and in sizes from 5-9/16 to 16 in. OD. Meets API 5L, Grades A or B, or API 5LX, Grades X42, X46, or X52 specifications. Just like our continuous buttweld line pipe, it's made at our Sparrows Point, Md., plant, from where we ship it all over the world.

BETHLEHEM STEEL

It gets hot in Pa., too! The scene above is southeastern Pennsylvania in mid-summer, and the day was a real sizzler. The crew welding this Bethlehem 36-in. pipe appreciated even the scant shade of an umbrella.

EFW pipe in sizes 18 to 42 in. OD

Bethlehem makes electric fusion-weld, expanded line pipe from 18 in. up to 42-in. OD. What's more, we can make it with ¾-in. walls.

We make large-OD, high-test line pipe in 40-ft. lengths, meeting all applicable API standards and lined at the mill if desired. We can also produce fabricated pipe to the above sizes using high-strength, alloy steel to achieve the desired physical properties with relatively thin walls. Substantial savings are possible.

For good, sound line pipe for any kind of pipeline, check with Bethlehem. Our nearest sales office can give you all the details.

BETHLEHEM STEEL

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Sales: Bethlehem Steel Export Corporation

Steel

for Strength
. . . Economy
. . . Versatility

NEW BELLOWS FLOW TRANSMITTER

gives you field indication plus convenience and precision

You get all the economy and convenience of pneumatic transmission and all the efficiency of the bellows meter body plus field indication, when needed, in the new Honeywell Bellows Flow Transmitter. Use it in any application to transmit flow or liquid level measurements in open or closed tanks.

This new meter has automatic ambient temperature compensation and two-way overload protection for 100% of span. Maintenance is greatly simplified by modular construction which lets you remove any major component by loosening two screws. All field adjustments are easily accessible, and a self-locking feature prevents upset after calibration adjustments are made.

New Bellows Transmitter is available with a concentric scale or as a non-indicator. It has 16 ranges—from 0-10 inches of water to 0-400 inches of water.

You can change ranges in the field simply by removing a single spring assembly and replacing it with an assembly of the desired range . . . adjust damping quickly and accurately, while the instrument is in operation . . . install the meter with either vertical or horizontal piping, so that it vents, drains and purges itself. The meter transmits with calibrated accuracy of ±0.5% of full scale, and indicates within ±1.0% of full scale.

For complete details on the new Bellows Flow Transmitter, call your nearby Honeywell field engineer. Or write MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.—In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

Honeywell

First in Control

SINCE 1885

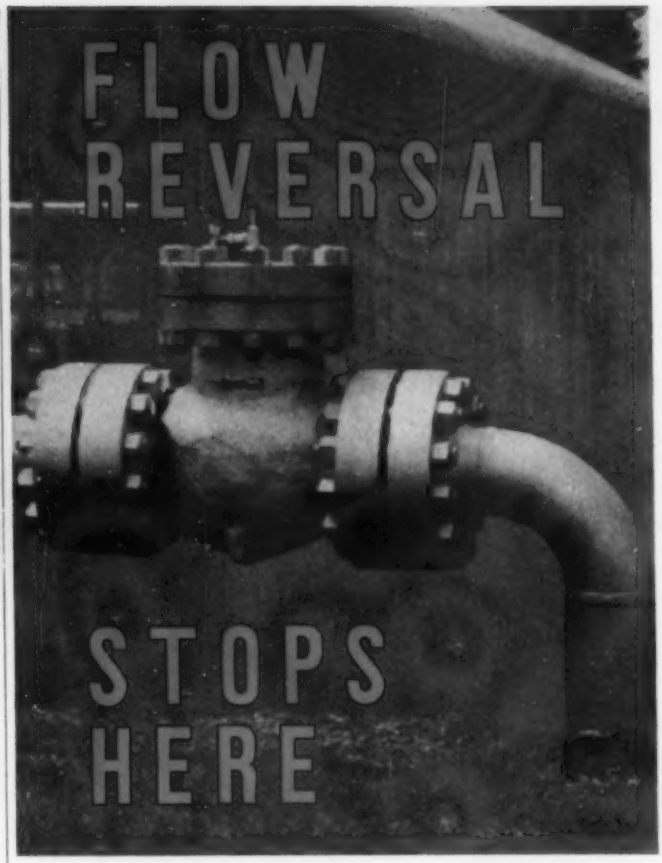
...so powerful it's called the bulldozer of chemical brush killers!

Unlike most other herbicides, new Urab Brush Killer penetrates straight down through soil strata . . . reaches deepest roots to give thorough kill of all types of brush, broadleaved trees, even evergreens. Urab is available in granular and pelleted forms for spot applications; as a liquid for spraying. Low rates per acre do the job. For use in non-crop areas. Write today for full information!

Allied Chemical

GENERAL CHEMICAL DIVISION
40 Rector Street, New York 6, N.Y.

*Trademark of Allied Chemical Corporation



Line back-surge is prevented by a positive, non-slam shut-off of the Daniel piston-controlled check valve. The "floating" piston rides well above the valve seat with line surges, eliminating chatter. Safely handles compressor and pump discharges, steam, gas and vapor flows.

A.S.A. pipeline, refinery and general use valves, 1" - 16", up to 6,000 p.s.i.g.

A.P.I. production flow line valves, 1" - 4", up to 10,000 p.s.i.g.

Send for Daniel Catalog Section "H".

DANIEL ORIFICE FITTING COMPANY

P. O. BOX 19097 • HOUSTON 24, TEXAS

For more data on advertised products, use Readers' Service Cards, last page.

to stay
in the black...
Specify
Leschen

RED-STRAND!

Black . . . the most attractive color in bookkeeping. There's no magic formula for staying in the black, but careful consideration of the right type and make of wire rope can cut costs substantially—10%, 20% or more.

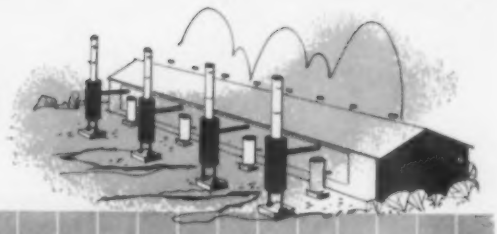
RED-STRAND users are accustomed to longer-than-expected wire rope service, because higher-than-catalog-rated quality is built into the rope. They know that Leschen distributors and field men make sure they have the best rope construction for the job at hand. They know, and you can too, that for wire rope and sling needs—specify RED-STRAND and stay in the black! For the name of your nearest Leschen distributor write: Leschen Wire Rope Division, H. K. Porter Company, Inc. 2727 Hamilton Avenue, St. Louis 12, Mo.

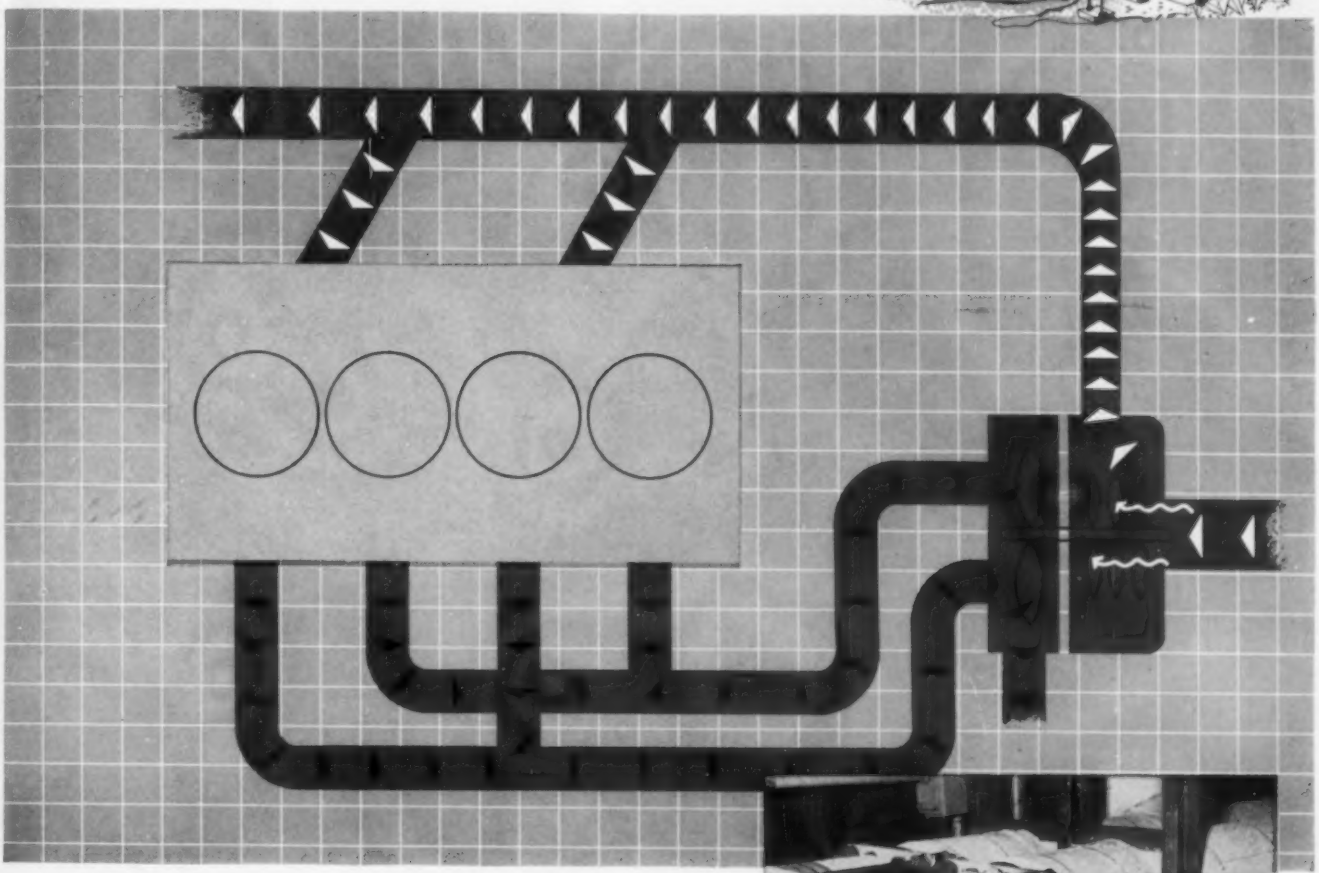
PORTER

LESCHEN WIRE ROPE DIVISION
H. K. PORTER COMPANY, INC.

Flexonics

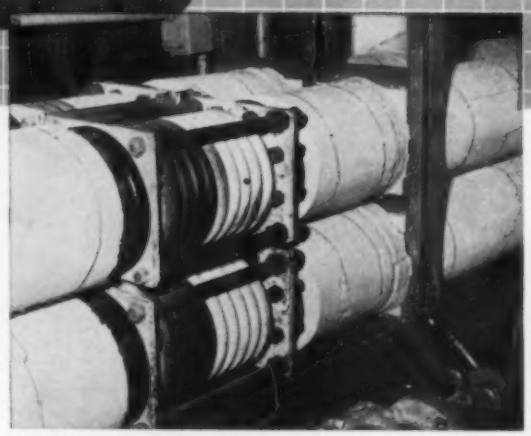
has the engineering experience to help you solve exhaust expansion problems when you turbocharge compressors





Here's a lively subject – *increasing gas pipeline capacity by turbocharging existing compressors in the field.* If you want the answers to the expansion problems that arise when the exhaust piping becomes an integral part of the operating loop, call on FLEXONICS engineers. They have the *specific* experience in this field that can mean actual dollar savings to you.

Mail the coupon today for your free copy of this easy-to-read report. It tells you the dollars-and-cents facts that led an important pipeline company to a complete turbocharging program.



Special-design FLEXONICS Expansion Joints in the exhaust piping of a newly turbocharged compressor station.

Flexonics

DIVISION OF CALUMET & HECLA, INC.
380 East Devon Avenue • Bartlett, Illinois

FLEXIBLE METAL and SYNTHETIC HOSE
EXPANSION JOINTS
BELLOWS • SPECIAL TUBULAR ASSEMBLIES

In CANADA
FLEXONICS CORPORATION OF CANADA, LTD.
BRAMPTON, ONTARIO

Flexonics
380 E. Devon Ave.
Bartlett, Illinois

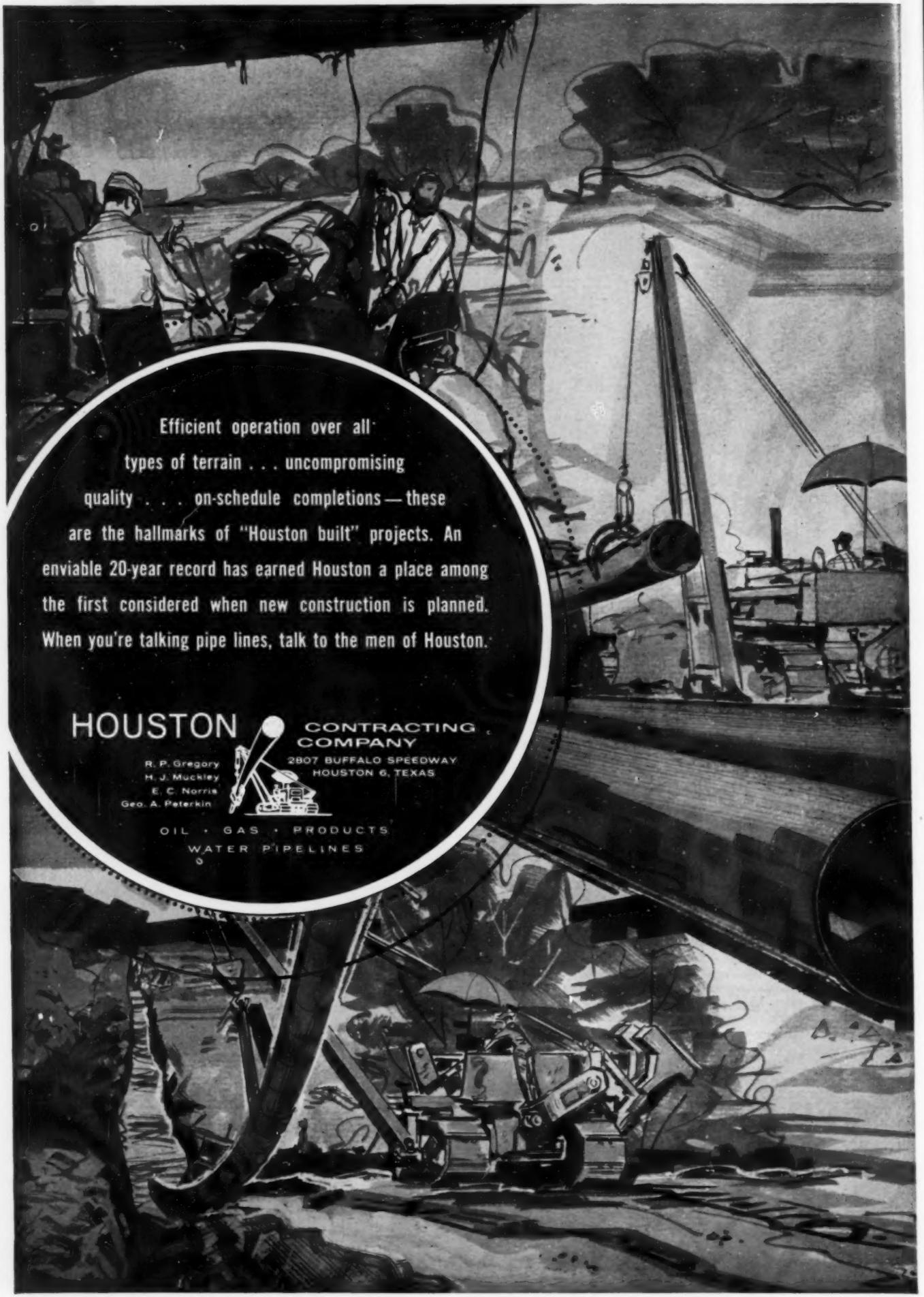
Please send me a copy of your Technical Bulletin No. 173, on turbocharging pipeline compressors.

Signed_____

Company_____

Street_____

City_____ State_____


Efficient operation over all types of terrain . . . uncompromising quality . . . on-schedule completions — these are the hallmarks of "Houston built" projects. An enviable 20-year record has earned Houston a place among the first considered when new construction is planned. When you're talking pipe lines, talk to the men of Houston.
HOUSTON
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H. J. Muckley
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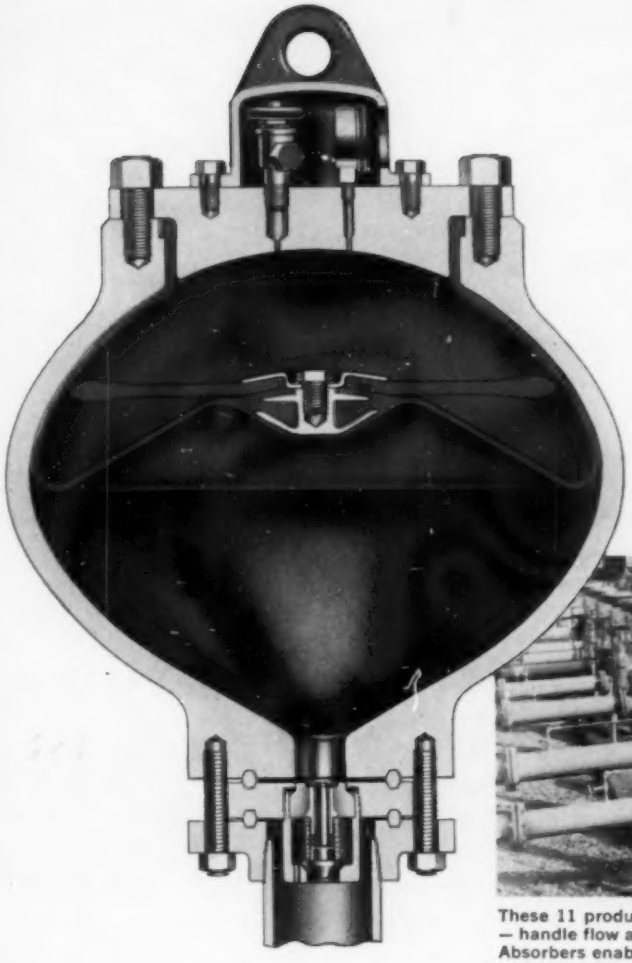
HOUSTON 6, TEXAS
OIL • GAS • PRODUCTS
WATER PIPELINES



prolongs life of pipelines, fittings and pumps... saves downtime... cuts maintenance costs!

These 11 product transfer lines — some over 1,000 feet long — handle flow at the rate of 1,600 gpm each, yet Hydril Surge Absorbers enable them to be closed in a fraction of a second without over-pressuring lines, fittings or metering equipment.

HYDRIL TYPE "K" SURGE ABSORBER

smooths out shock and pulsation in pipelines

QUICK-CLOSING VALVES and piston-type pumps punish pipelines by imposing sudden peak pressure loads. Unless these surges can be absorbed or smoothed out, pipe and fittings are exposed to stresses which may cause costly failure.

Hydril Type "K" Surge Absorbers are successfully controlling many types of line surge and pulsation in petroleum product handling lines, water pumping systems and oilwell repressuring programs. Simple design and construction assures long, trouble-free operation. This same oil field-proven Hydril design has been used for many years as a pulsation dampener on high-pressure oilwell mud pumps. Servicing, though rarely required, is readily performed without special tools and without shutting down the system or removing the unit from the line. Available in a wide range of sizes and pressure ratings.

Another dependable Hydril pressure-control product

For more detailed information on Hydril Surge Absorbers, consult your Pipeline or Composite Catalog... or call your Hydril Representative

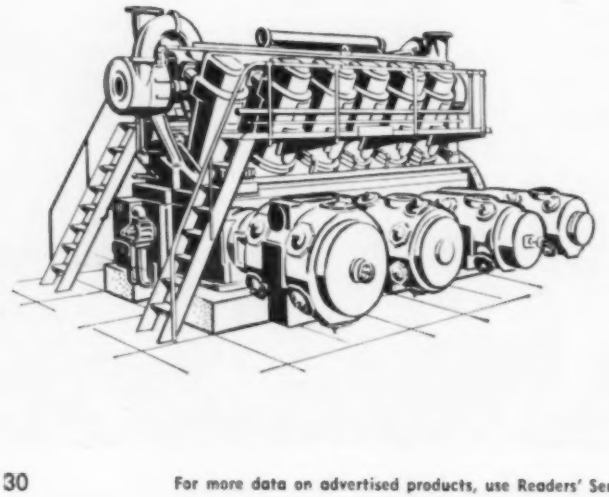
HYDRIL COMPANY

714 West Olympic Boulevard, Los Angeles 15, California

Factories: Los Angeles, Calif.; Houston, Texas

SALES OFFICES: Bakersfield, Los Angeles, Ventura, California; Harvey, New Iberia, Louisiana; Oklahoma City, Tulsa, Oklahoma; Rochester, Pennsylvania; Corpus Christi, Dallas, Houston, Midland, Odessa, Texas; Casper, Wyoming; Farmington, New Mexico; New York, New York; Calgary, Edmonton, Canada.

"SHOPPING CENTERS"



Across the United States and Canada, and throughout the world, Ingersoll-Rand's growing network of warehouses and service centers assures maximum availability for your I-R gas-engine compressors.

From these modern, well-equipped facilities you get prompt shipment of replacement parts and fast engineering service whenever they're needed, to keep your machines on the line year after year.

The result is double-protection for your oper-

Branch offices and warehouses are located for quick response to every need, from application engineering to installation and maintenance. Large stocks of factory-made parts are kept ready for immediate supply.

that keep your engine-compressors on-line!

ation — the inherent reliability of I-R 4-cycle V-angle engine-compressors, backed up by Ingersoll-Rand's newly-expanded and still-growing service organization. I-R builds engine-compressors from 120 to 4500 hp, and also offers the *most complete* line of other compressors, in reciprocating, centrifugal, axial-flow, rotary and thermal types; there are units from ½ to 25,000 hp, for pressures from one micron to 125,000 psi. Call your I-R man today for help with your compression problems.

Ingersoll-Rand

239A6 11 Broadway, New York 4, N.Y.

The World's Most Comprehensive Compressor Experience

X-RAY VIEW REVEALS

10 LINK-BELT design features that reduce your downtime...cut your costs

1 Full-Function Design practically doubles upper machinery life. Separate shafts... separate gears... separate clutches transmit power for *each* machine function. Only the components in actual use are under load... other shafts and clutches remain motionless while gears run free on antifriction bearings. Full-Function Design has been proved in the field year after year to be superior to conventional design.

2 Speed-o-Matic power-hydraulic controls reduce downtime! In addition to eliminating up to 150 mechanical parts, the Speed-o-Matic system is unaffected by normal changes in climate or temperature. Only a seasonal oil change is required... no need to prime or bleed the system.

3 Speed-o-Matic clutches require little operator attention! Hydraulic cylinder pistons automatically compensate for normal lining wear, heat expansion or weather changes. Minor adjustments may be weeks, even months apart.

4 Clutches are interchangeable on a given machine (including components of each) for reduced parts inventory. Located *outside* the side housings, clutches are readily accessible... can be easily pulled.

5 Extremely short drum shafts minimize bending and flex! Tandem drum arrangement allows closer spacing of the side housings and the side housing bearings, resulting in more rigid supports.

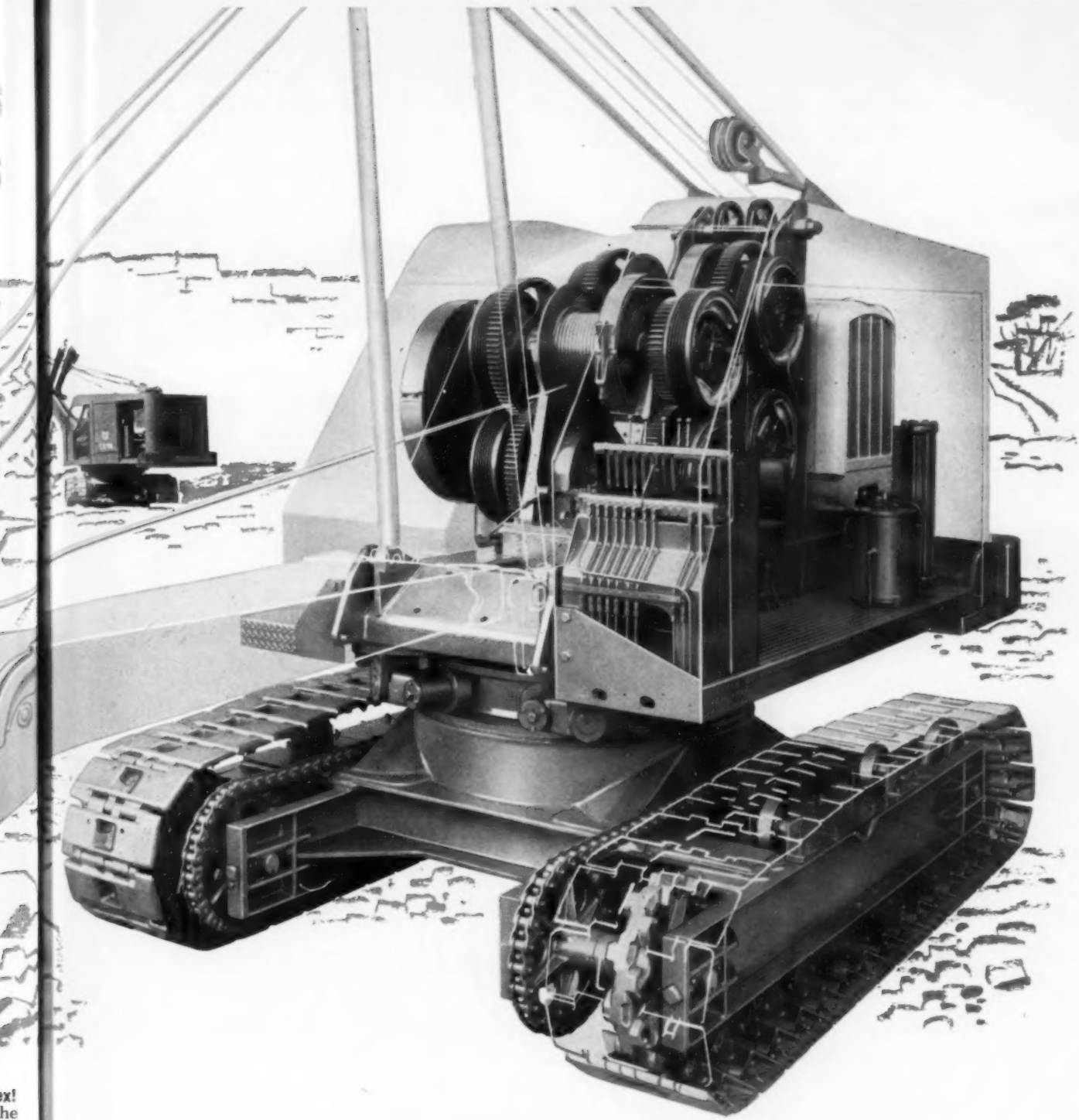
6 Fast, simple removal of any operating shaft! Brake drums, clutch spiders and bevel gears are involute-splined to the shafts... no press fits or keyways used.

7 No heat transfer between clutch drums and brake drums! Clutch drums are separated from gears and brake drums to minimize clutch and brake wear.

8 Long-life mechanical drum brakes are easier to operate and service! Unlike brakes on some shovel-cranes, all moving parts are mounted on antifriction bearings to reduce wear.

9 Lower machinery fully protected against dirt and other foreign material! Hydraulic power steering and automatic brakes are completely enclosed in a clean, flat carbody.

10 Adjustable, conical hook rollers follow a true circular path... no scuffing or peening. Double flange turntable eliminates center pivot up-pull or wear-causing bind or stress.

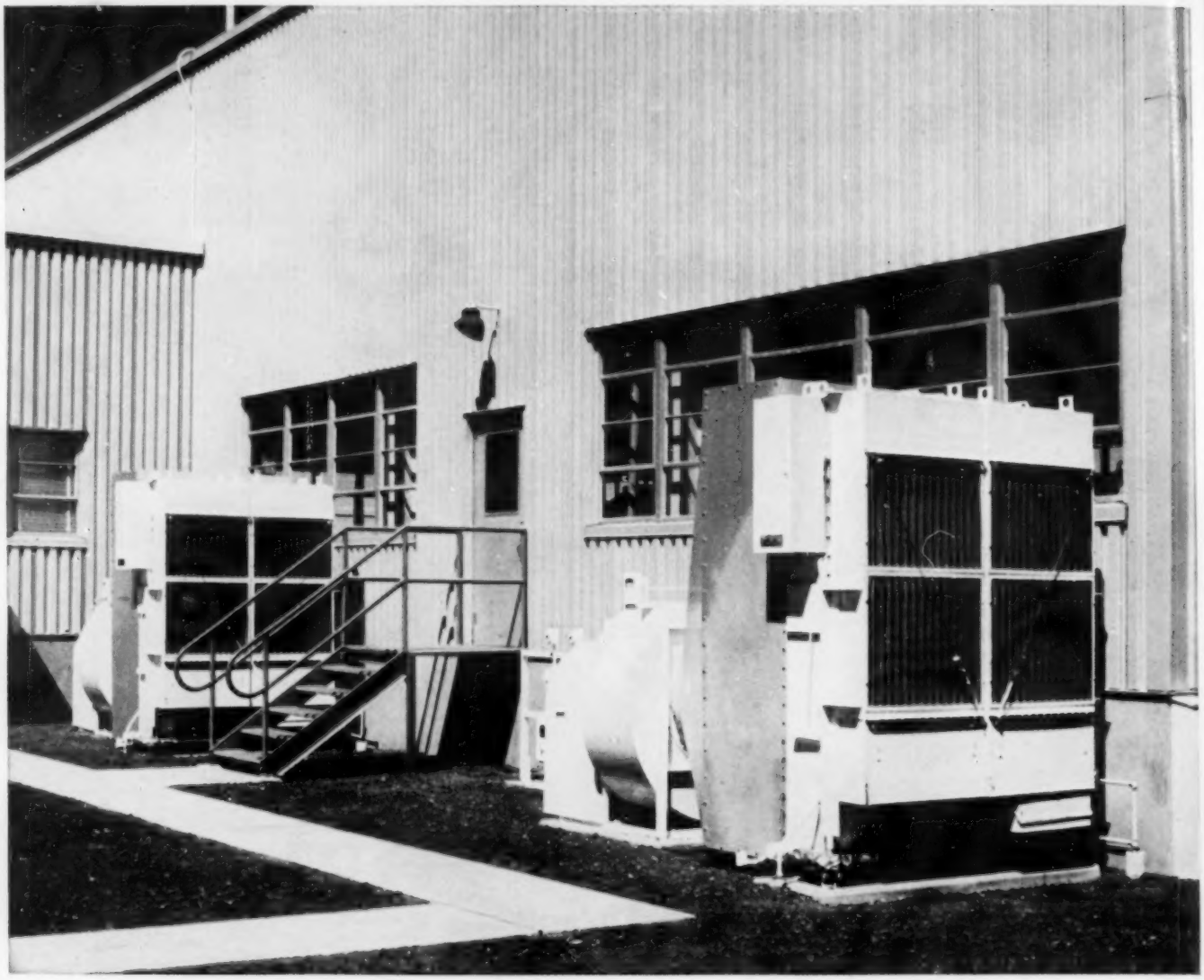


NOTE: The entire upper machinery of the Full-Function Design models (8- to 40 ton capacity) can be field-stripped, piece by piece, without removing major portions of the cab. For fully-illustrated, descriptive literature on the various models in the Link-Belt Speeder line, see your distributor. Or write: Link-Belt Speeder Corporation, Cedar Rapids, Iowa. 117-61N

LINK-BELT SPEEDER

It's time to compare . . . with Link-Belt Speeder

For more data on advertised products, use Readers' Service Cards, last page.



AUTOMATIC GUARDS
for automatic pumping station

AAF MULTI-DUTY filters operate 'round-the-clock at El Paso Natural Gas Company's Seligman Station, at Seligman, Arizona. They assure an uninterrupted supply of dust-free intake air for the two 5,000-hp Cooper-Bessemer compressors.

Clean air is essential for safe, efficient operation of these big compressors, and the AAF MULTI-DUTY provides this automatically. Its special self-cleaning filter curtain provides constant high efficiency and uniform air delivery under any conditions. And the MULTI-DUTY requires practically no maintenance. Periodic removal of sludge is all that's ever needed.

Whatever your requirements in clean air, American Air Filter has the right equipment for your operation. AAF is the *one* company that makes *all kinds* of filters!

Get complete information from your nearby AAF representative; or write Robert D. Moore, American Air Filter Co., Inc., 450 Central Ave., Louisville, Ky. In Canada: American Air Filter of Canada, Ltd., 400 Stinson Blvd., Montreal 9.

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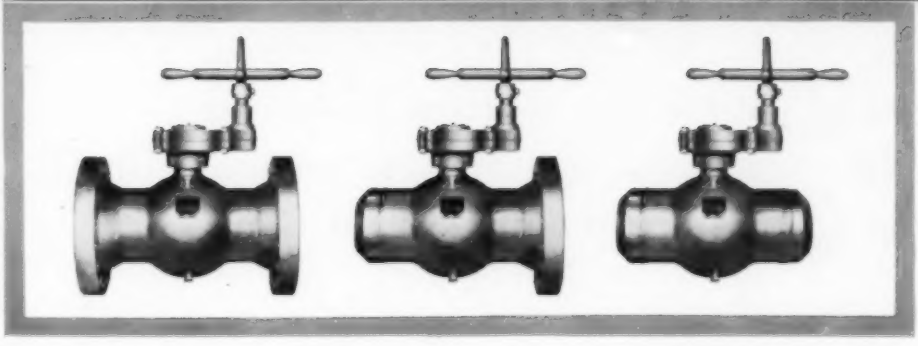

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PIPE LINE PANORAMA

Soviet Pipe Lines Threaten Free World Markets . . . Russia has allocated 12 billion rubles ($3 billion) to expand petroleum trunk-pipe line system from 9,000 miles in 1958 to 28,000 miles by end of '65. Plans include 11,000 miles of crude oil lines, 8,000 miles of product lines, more than 100 pumping stations with capacity exceeding 1.2 million kilowatts—to carry Volga-Urals petroleum to Baltic, East Europe and Russian far east.

New pipe lines to Baltic and East Europe hold special significance for Free World petroleum marketers in West Europe. Reasons: Baltic line will strengthen competitive position of Communist oil in Scandinavia and other European countries. East Europe line could be extended into West Germany.

U.S. Government projections show Russia may have 359 million barrels of exportable crude oil by '65. East Europe pipe line could take 131-146 million barrels of surplus, leaving about 213-228 million barrels to drop on Free World market.

Construction Application Log Jam Approaches $1 Billion . . . At April's end, Federal Power Commission reported 199 applications involving 7,093 miles of pipe line construction and 664,980 compressor horsepower were still hanging fire. Total value: $874.7 million—up $3.5 million and two applications from total reported on March 31.
Independent producer gas certificate applications totaled 2,973 on April 30.

New Automatic Welding Machine to be Field-Tested . . . After passing laboratory test with flying colors, Linde Company's automatic machine for welding 18-36 inch lines will soon be field-tested. So will another machine for welding smaller diameter pipe.
"Big-Inch" machine, developed in close cooperation with Bechtel Corporation, will be mounted directly on pipe, will produce uniform bead as it moves around pipe—is expected to reduce welding manpower requirements about 50 percent.

Already field-tested are Esso Research-Air Reduction's and Price-Crose-Perrault-Hobart's automatic field welding machines. Lincoln Electric's vapor shielded arc welding machine is well along in development stage.

Pipe Line Briefs . . . Hood Company has been awarded contract to trench and backfill about 1,800 miles of cable at Montana Minuteman missile project . . . **Look for Joseph Swidler and Howard Morgan to be seated on Federal Power Commission shortly,** bringing staff to full five-man complement for first time in 14 months; but, then will come the naming of successor to Commissioner Arthur Kline whose term expires later this month . . . **Pipe line contractors are urged to turn down union demands** to put local union foremen on jobs; undesirable precedent will be set if such demands are met. No National Pipe Line Agreement requires that any foreman employed on pipe line construction be a member of any union . . . **Area-wide rate hearings** to determine natural gas prices at the wellhead in southern and offshore Louisiana are slated to be held by FPC June 26 at Baton Rouge; about 220 producers are involved . . . **Colorado's Democratic Senator Carroll has added new natural gas bill to heap already in hopper;** measure would tighten controls by barring a natural gas company from making any rate increase until it was approved by FPC.

Digest: A Report On Gas Storage In Underground Water Reservoirs

Moving gas fields into water sands near markets is paying off

By E. Vincent Martinson
Northern Natural Gas Company, Omaha

WITH THE EXCEPTION of an area in Siberia, many of the large gas companies' market territories have the widest temperature spread on earth. This is especially true for those companies operating in the mid-continent region of the United States. To alleviate this problem, several of these companies have moved natural gas fields hundreds of miles closer to market—to areas which had been disappointingly devoid of gas or oil.

GROWTH OF GAS STORAGE IN AQUIFERS

The latest type of underground natural gas storage reservoir to find widespread application is the petroleum-barren aquifer. An aquifer is defined as a water-bearing bed or stratum of porous rock extending for many miles. For natural gas storage use such a reservoir must exist in an anticlinal fold or other structure or trap.

History. Storage of natural gas in an aquifer was first tried in 1946 by Louisville Gas and Electric Co. Gas was first stored at a depth of 650 feet in the Doe Run field located on the Kentucky-Indiana border. The operation has been successful.

Growth of gas storage in aquifers by years is illustrated in Figure 1. The sudden spurt which came in 1953 was due to the start of the gigantic Herscher, Ill., storage project by Peoples Gas, Light and Coke Co. of Chicago.

The companies operating and developing gas storage in aquifers together with pertinent data on their separate fields are listed in Figure 2. **Note that aquifer storage fields in the U.S. have to date stored a maximum of 155,664,000 Mcf and plan an additional 470,878,000 Mcf for an ultimate of 626,542,000 Mcf.**

These capacities have resulted in a total maximum seasonal send-out of 35,280,000 Mcf and plans are for a seasonal ultimate of more than 183,000,000 Mcf from the same fields. This achievement is especially outstanding as most of the growth has been within the last eight years.

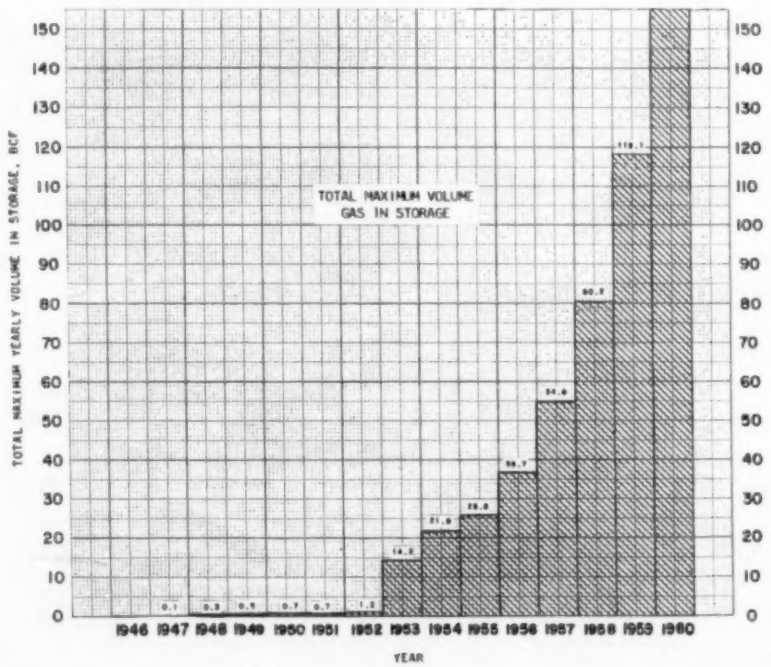


FIGURE 1—How gas storage in aquifers has grown. The spurt in 1953 came as the Herscher Dome storage field went into service. The volumes shown are in billions of cubic feet.

CASE HISTORIES OF AQUIFER GAS STORAGE PROJECTS

Northern Natural Gas Company. Northern Natural's 730,000 house-heating customers use about 15 times as much gas on the coldest day of winter as they do on the hottest day of summer. Obviously, transmission capacity must be adequate to serve these customers' needs on the coldest day.

Northern was not fortunate enough to have depleted oil or gas fields near its large market centers, and has had to resort to the development of large-scale underground storage in water-filled formations occurring in suitable anticlinal folds. **As a result, Northern has moved a natural gas field 700 miles closer to market—to the heart of the Iowa tall corn country.**

Exploratory drilling in Iowa resulted in the delineation of a doubly plunging asymmetrical anticline located about 35 miles west of Des Moines or five miles north of Redfield.

Reservoir Characteristics. This is typical of the anticlinal aquifers in which gas is stored in a porous water-bearing sandstone capped by an impermeable caprock. Note that Northern is storing gas in two separate reservoirs: the St. Peter, a 37-foot-thick sandstone at 1,745 feet and the Mt. Simon, a 110-foot sandstone at 2,648 feet. Hydrostatic head of the two sections is 715 psia for the upper and 1,115 psia for the lower. The areal extent of the reservoirs is about 7,100 acres. Northern has 12,500 acres under lease.

Testing the Reservoirs. Gas injection into the St. Peter was started in January 1955, and continued until September 1956. The tests revealed that the sandstone would take and give up gas and that the caprock seemingly was satisfactory for holding gas. In September 1956, a 20-inch line was run from a nearby compressor station and tied in to 12 injection-withdrawal wells. In addition, observation wells had been completed in the reservoir skirting the field and in porous formations above the caprock. (These facilities have now been expanded to 32 injection-withdrawal wells equipped with water knockout, metering and heating equipment.)

After testing for about 1½ years, gas was discovered migrating upward 300 feet from the St. Peter formation to a porous dolomite, the Elgin member of the Maquoketa formation. Withdrawal wells have been drilled to this zone to control gas pressure and prevent lateral escape from the structure. As the Elgin has a limited connection with the St. Peter reservoir, the two are operated as a single reservoir system on withdrawal in the wintertime.

There has been no evidence of gas in any of the other porous zones above the Elgin or between the other horizons.

Small-scale testing of the Mt. Simon reservoir was started in July 1957, and facilities for large-scale testing put into operation August 1958. At present, a total of 28 Mt. Simon injection-withdrawal wells and the attendant gathering lines, a 4,000-horsepower compressor station and dehydration plant are in operation for large-scale testing.

There has been no evidence of leakage of gas upward from the Mt. Simon.

Redfield Performance. The maximum combined total volume in storage in both reservoirs was 68,000,000 Mcf last fall. This was divided by reservoirs with 36,000,000 Mcf in the St. Peter-Elgin and 32,000,000 Mcf in the Mt. Simon.

The maximum daily withdrawal during the past winter season was 165,000 Mcf. This is significant as it represents 11 percent of the maximum daily sales of the entire company system. The Redfield reservoirs furnished a total of 11,500,000 Mcf during the past 1960-61 heating season in spite of an unusually warm winter.

The St. Peter-Elgin system withdrawal rates average about 75,000 Mcf per day during continuous day-after-day operation. Similarly, and generally simultaneously, the deeper Mt. Simon reservoir furnishes about 60,000 Mcf per day.

It is estimated that the ultimate capacity of the St. Peter reservoir will be 40,000,000 Mcf and that of the Mt. Simon 100,000,000 Mcf for a total of 140,000,000 Mcf. However, there is a possibility that it may never be necessary to fill the Mt. Simon reservoir to its estimated maximum capacity. When fully developed, the two reservoirs will have a maximum daily deliverability of about 390,000 Mcf and continuous daily deliverability of about 300,000 Mcf. Ultimately, the total seasonal withdrawals should exceed 45,000,000 Mcf. The field will be delveloped as markets develop and should reach full capacity by 1966.

New Gas Storage Prospects. Northern has made a thorough search for new aquifer storage areas in northern Iowa, and several prospects have been uncovered. One, located 12 miles from Fort Dodge, has been delineated by test drilling and coring, and small-scale gas injection will be started as soon as leasing has been completed.

Louisville Gas and Electric Company. This company started experimentation with storing gas in a limestone formation containing salt water in early 1946, in the Doe Run field.

Originally, this area had one well which at the turn of the century had produced about 160,000 Mcf of gas over a number of years. Salt water moved into the anticline, replacing the small amount of gas produced from the lime stone at a depth of 665 feet. The reservoir varies from one to 20 feet in thickness, has an average porosity of 15 percent and an average permeability of 1,000 millidarcys. To date, more than 3,700,000 Mcf has been in storage and it is anticipated the capacity will exceed 4,000,000 Mcf.

The development of this field was not without problems in reservoir mechanics and leakage from old unrecorded wells. For lack of precedent knowledge, many methods of solution had to be developed by trial and error. By employing periodic well cleaning, limited "dewatering" and improved methods of operation, the aquifer has been developed to provide a maximum daily deliverability of about 50,000 Mcf per day from wells varying in size from 1,000 to 25,000 Mcf per day open flow capacity. The seasonal withdrawal of 2,400,000 Mcf is unusually high for an aquifer having had a maximum seasonal inventory of only 3,700,000 Mcf. Seasonal withdrawals have exceeded 75 percent of total inventory in the Doe Run field.

Natural Gas Storage Company of Illinois. The first *major* aquifer gas storage field to be placed in service was the Herscher Dome, about 70 miles from Chicago. The field is operated by Natural Gas Storage for Natural Gas Pipeline Company of America.

The presence of the Herscher anticline was well known when the company started investigations in 1951. By the end of 1952, 104 shallow test wells had been drilled to the Galena and four deep tests had been drilled and cored through the Galesville sandstone. Analyses of cores indicated the Galesville should be a suitable reservoir.

Injection into the Galesville was started April 1, 1953, at 15,000 Mcf per day into five top structure wells. A compressor plant was put in service in July 1953, and injection rates were stepped up to 200,000 Mcf per day.

The Galesville sandstone is 1,750 feet deep at the crest; hydrostatic pressure was originally 715 psia. To date, the reservoir inventory has been as high as 35,500,000 Mcf and the maximum daily withdrawal has been a whopping 471,000 Mcf. The ultimate capacity is estimated at 90,000,000 Mcf, yielding a daily withdrawal rate as high as 800,000 Mcf.

Leakage of gas from the Galesville reservoir upward to beneath the Maquoketa shale, about 250 feet beneath the surface, was discovered after several months of injection. However, a recycling system of wells, gathering lines and compression facilities has been constructed for an economical solution of the problem.

The lower gas storage aquifer in the Herscher anticline is the Mt. Simon sandstone found at a depth of 2,440 feet. Gas was first injected into the Mt. Simon November 1957, against a hydrostatic pressure of 1,077 psia. This lower reservoir has an estimated ultimate capacity of 67,000,000 Mcf and ultimately over 200,000 Mcf per day withdrawal rate on peak

Company	Field	State Field Located	Reservoir	Geologic Age	Lithology of Reservoir	Type Structure	Reservoir Depth At Crest, Feet	Original Hydrostatic Pressure psia	Date Injection Started	Maximum Volume Gas in Storage Billion C. F. @ 14.73# To Date	Maximum Volume Gas in Storage Billion C. F. @ 14.73# Planned	Maximum Seasonal Withdrawal Volume Billion C. F. @ 14.73# To Date	Maximum Seasonal Withdrawal Volume Billion C. F. @ 14.73# Planned	Maximum Daily Volume Delivered Mcf @ 14.73# To Date	Maximum Daily Volume Delivered Mcf @ 14.73# Planned
Arkansas Western Gas Company	Carrollton	Arkansas	Gunter	Ordovician	Sandstone	Faulted Anticline	2,228	760	April, 1959	1.300	10.000	0.021	0.400	5,000	5,000
Central Illinois Light Company	Glasford	Illinois	4 Prospects			Cryptovolcanic?		Unknown	None	None	Unknown	None	Unknown	None	Unknown
			Niagaran	Silurian	Dolomite		800								
			Trenton	Ordovician	Dolomite		1,100								
			St. Peter	Ordovician	Sandstone		1,500								
			Mt. Simon	Cambrian	Sandstone		2,300								
Laclede Gas Company	Florissant	Missouri	St. Peter	Ordovician	Sandstone	Dome	1,350	570	Dec., 1955	11.000	40.000	3.500	7.000	150,000	300,000
	Florissant	Missouri	Roubidoux	Ordovician	Sandstone	Dome	1,850	801	July, 1960	1.000	30.000	None	Unknown	None	Unknown
Louisville Gas and Electric Company	Doe Run	Kentucky-Indiana	Jeffersonville and Upper Brownsport	Devonian-Silurian	Limestone	Anticline	664	215	June, 1946	3.719	4.000	2.357	2.800	48,000	50,000
Mississippi River Fuel Corporation	Waterloo	Illinois	Roubidoux	Ordovician	Gasconade Dolomite	Elongated Anticline	1,500	547	1951	0.300	0.300	1.500	1.500	20,000	20,000
The Montana Power Company	Madison	Montana	Bozeman "Lake Beds"	Tertiary	Sandstone	Monocline Pinch-out	900	390	Fall, 1952	5.329	6.100	0.360	1.160	28,300	45,000
Natural Gas Storage Company of Illinois	Herscher	Illinois	Galesville	Cambrian	Sandstone	Asymmetrical Anticline	1,750	715	April, 1953	35.306	89.508	9.842	9.945	470,802	596,718
	Herscher	Illinois	Mt. Simon	Cambrian	Sandstone	Asymmetrical Anticline	2,440	1,077	Nov., 1957	16.310	66.634	1.676	3.978	65,052	99,453
Northern Illinois Gas Company	Troy Grove	Illinois	Mt. Simon	Cambrian	Sandstone	Dome	1,421	615	July, 1958	11.1	102.500	1.100	61.000	153,000	900,000
	Crescent City	Illinois	St. Peter	Ordovician	Sandstone	Dome	1,216	490	None	None	60.000	None	30.000	None	600,000
Northern Natural Gas Company	Redfield	Iowa	St. Peter	Ordovician	Sandstone	Doubly Plunging Anticline	1,745	715	Jan., 1955	36.1	40.000	8.3	15.000	110,000	130,000
	Redfield	Iowa	Mt. Simon	Cambrian	Sandstone	Same	2,655	1,115	July, 1957	31.7	100.000	5.4	30.000	134,000	260,000
	Vincent	Iowa	St. Peter	Ordovician	Sandstone	Same	1,215	480	Planned for Summer, 1961	None	Unknown	None	Unknown	None	Unknown
Panhandle Eastern Pipe Line Company	Waverly	Illinois	St. Peter	Ordovician	Sandstone	Asymmetrical Anticline	1,830	747	1954	N.A.	20.000	None	10.000	None	200,000
Peoples Gas Light and Coke Company	Mahomet	Illinois	St. Peter	Ordovician	Sandstone	Asymmetrical Anticline	1,539	605	Planned for Summer, 1961	None	Unknown	None	Unknown	None	Unknown
Pleasant Valley Gas and Oil Company	Jackson Prairie	Washington							None	None	25.000	None	10.000	None	100,000
Texas Gas Transmission Corp.	Wilfred	Indiana	Geneva	Devonian	Limestone & Dolomitic Limestone	Dome	1,930	865	April, 1959	2.500	2.500	1.224	1.224	30,600	30,600
Washington Gas Light Company	Brandywine	Maryland	Patuxent	Cretaceous	Sandstone	Doubly Plunging Anticline	1,290	525	None	None	30.000	None		None	
Total Volumes										155.664	626.342	35.280	184.007	1,184,754	3,346,771

FIGURE 2—Natural gas storage in petroleum barren aquifers in the United States.

days. The maximum daily volume delivered to date is 65,000 Mcf.

Success of the Herscher project prompted The Peoples Gas Light and Coke Co. to search for additional storage aquifers. The company found a promising field in the northwest corner of Champaign County, Illinois. The St. Peter sandstone was discovered at 1,530 feet and there is every indication that it will be suitable for gas storage. Injection on a small scale will start this summer.

Northern Illinois Gas Company. This company's ability to meet all the needs of its market can be traced partially to increase in daily gas supplies and the company's share of Herscher gas. However, most credit goes to the placing of the Troy Grove underground gas storage reservoir in regular operation.

Northern Illinois Gas injected into the Troy Grove aquifer on a pilot basis beginning in July 1958. The reservoir was put in regular operation in December 1960, and its performance has been better than expected.

Last winter, as much as 153,000 Mcf was withdrawn in one day, Withdrawals of 100,000 Mcf per day on several occasions proved the reservoir's performance. A test withdrawal for 20 hours at a rate of 170,000 Mcf per day was entirely satisfactory. Additional equipment is being installed to make this facility even more useful in meeting the requirements of customers next year.

Gas for injection into the Troy Grove storage reservoir is carried in a 30-inch diameter pipe line from the Natural Gas Pipeline Company of America's main line five miles south. Another 30-inch diameter line carries withdrawal gas to the heart of the company's service area near LaGrange.

At the end of the 1960 injection season, a maximum of 11,100,000 Mcf of gas was in storage. Plans are to develop the reservoir to 25,000,000 Mcf in storage, delivering an anticipated daily volume of 250,000 Mcf. If development continues successfully, these volumes may be increased appreciably. At ultimate development, the working gas is estimated at 61,000,000 Mcf per season.

The extremely high demands during winter months have made it apparent that Northern Illinois must find other places to store large volumes of gas. The company completed a series of test wells in an area about 25 miles south of Kankakee. An anticlinal structure was delineated, and permission has been requestd from the Illinois Commerce Commission to test, develop and operate this storage reservoir.

Recently, publicity has been given to an experiment in a revolutionary type of underground aquifer gas storage now being conducted by the Northern Illinois Gas Company. This project is aimed at determining if gas can be stored under water pressure beneath a flat caprock, instead of in the usual structural trap.

Location of the project is Matteson, Ill., 12 miles south of Chicago, at one of Northern Illinois' compressor station sites.

This is a test of a theory that a wall of water can control a mass of gas keeping it collected in the form of a huge bubble under the caprock. Eight water-injection wells have been drilled in a circle about 1,700 feet in diameter. A gas-injection well is located in the center of the circle and five observation wells are spaced across half of the gas-water configuration. While under test, air instead of gas is being pumped into the 150-foot thick porous sandstone found at a depth of about 1,000 feet. However, difficulty with increase of pumping pressure during water injection has retarded testing progress.

It is too early to draw conclusions on the feasibility of this new idea, but if the water pressure proves dependable and economical for properly confining the air, it will open up the possibility of using flat or only partially closed aquifer resevoirs for gas storage.

The significance of underground storage to Northern Illinois is made clear by the fact that peak day sendouts have increased 250 percent in the past six years and its deliveries are predicted to expand at about 10 percent per year in the future.

The Montana Power Company. In 1951, Montana Power started a search for an aquifer gas storage field near Butte to help meet peak load requirements, it resulted in the discovery of an anticlinal Tertiary "nose" located about 10 miles southeast of Three Forks, Mont. Clean, porous sand was found several hundred feet thick interspersed with numerous beds of sticky bentonitic shale.

In 1952, gas injection was started into a sand lens at a depth of 1,145 feet. The next year gas was found in a shallower sand at about 950 feet and all wells were recompleted in this shallower sand. Because of this, it also became necessary to revamp surface installations resulting in the delay in development of the field.

Injection and withdrawal of gas has taken place seasonably since 1952, with a growth in maximum inventory to almost 6,000,000 Mcf.

Laclede Gas Company. Laclede serves all of metropolitan St. Louis and surrounding suburban communities. The tremendous growth of population in this area since World War II, plus the growth of demand for natural gas for homes and industry, rapidly absorbed additional supplies created by a new pipe line. Studies proved that underground storage would be the only economical solution to this predicament. There were no depleted gas fields in the area. However, geological investigation revealed the existence of a dome-like anticline just 20 miles north of St. Louis near the suburb of Florissant, practically in their own backyard!

Laclede geologists commenced shallow core drilling in the fall of 1952, and proved the Florissant structure on shallow strata. Subsequent deep drilling and coring to granite at a depth of 3,324 feet proved a suitable aquifer, the St. Peter sandstone, at 1,400 feet and the Roubidoux sandstone at 1,870 feet.

Development took place rapidly and in December 1955, initial gas injection was started. Today, 14 injection-withdrawal wells coupled with more than 4,700 compressor horespower handles the gas for this operation. In addition, 14 observation wells have been completed.

A maximum of 11,000,000 Mcf of gas has been in the St. Peter sandstone and withdrawals this past winter reached a volume of 3,500,000 Mcf. A maximum peak day withdrawal of 150,000 Mcf has been reached.

The Roubidoux is now being tested. Four injection-withdrawal wells and three observation wells are in service. The highest inventory was 1,000,000 Mcf.

Laclede's Florissant storage has made possible the addition of over 100,000 residential heating customers.

Mississippi River Fuel Corporation. Gas injection into the water-

filled Roubidoux-Gasconade dolomite in a closed dome structure located three miles north of Waterloo, Ill., was started in 1951 by Mississippi River Fuel. The maximum amount of gas in storage at any time is considered to be 250,000 Mcf; however, because of the alternate injection and withdrawal of gas throughout the season, the seasonal withdrawal total is about 1,500,000 Mcf.

In addition to the Waterloo field, Mississippi River Fuel is considering development of additional aquifer gas storage in Illinois. Injection of gas for testing purposes will be started when satisfactory FPC authorization has been granted.

Panhandle Eastern Pipe Line Company. The company discovered a dome-like structure 1½ miles from Waverly, Ill. The St. Peter sandstone occurs at 1,830 feet and is about 235-feet thick. The caprock is 100-feet thick and the anticline covers about 8,000 acres.

Testing started in 1954, and slow methodical injection and observation has continued since. Some leakage into the overlying Joachim formation will likely require a collection system. In April, the FPC authorized Panhandle to construct facilities for injection and withdrawal of 6,000,000 Mcf of gas per year.

It is anticipated the Waverly field will have a seasonal working storage of 10,000,000 Mcf available at withdrawal rates as high as 200,000 Mcf per day during peak demand. To achieve this performance, the planned maximum sum of total cushion and working storage volumes is 20,000,000 Mcf. The ultimate storage capacity of the the St. Peter reservoir is estimated to be more than 84,300,000 Mcf.

Washington Gas Light Company. The company is seeking to develop an aquifer storage field in an anticline located 12 miles southeast of Washington D.C., one mile from Brandywine, Md. The structure has been delineated and the need has been established, but to date, the company has been unable to secure all storage rights necessary to proceed with the development of the field.

The Brandywine prospective gas storage reservoir is the Patuxent sandstone approximately 1,300 feet deep. The ultimate capacity is estimated at 30 billion cubic feet. Exploratory shallow wells were drilled to delineate the structure and 13 deep wells have been completed to study the storage zone including test injections with inert gas. Technically, success of the storage reservoir appears encouraging.

About the Author

E. V. Martinson is director of Underground Storage Division of Gas Supply Department for Northern Natural Gas Company. He has worked with the development of gas storage in aquifers since 1951. A graduate of the University of Nebraska, Martinson is a registered professional engineer in Nebraska. He has served on the Underground Storage Committee and its subcommittee on Gas Storage Mechanics for the American Gas Association.

Arkansas Western Gas Company. The company first injected into its Carrollton dome field, located in Boone County, Arkansas, in April 1959. The reservoir under test is the Gunter sand, occuring at a depth of 2,228 feet. It has an average thickness in the area of about 100 feet.

To date, as much as 1,300,000 Mcf of gas has been in storage in the Carrollton dome and it is anticipated the ultimate capacity will be 10,000,000 Mcf permitting total withdrawals of 4,000,000 Mcf per season.

Pleasant Valley Gas and Oil Company. This company has completed engineering and leasing for development of an aquifer natural gas storage field in a structure located four miles south of Chelhalis, State of Washington. The company is now in the process of working out plans with other interested groups for participation. As yet, no gas has been injected. Plans are to develop it to a total capacity of at least 25,000,000 Mcf of which seasonal withdrawals are estimated at 10,000,000 Mcf at withdrawal rates of at least 100,000 Mcf per day.

Central Illinois Light Company. The company began a concentrated search for an aquifer underground gas storage reservoir in 1957, in western Illinois. The exploration resulted in the delineation of a likely prospect.

The structure may be unique in this area—its circular nature and sharply dipping flanks suggest a volcanic origin.

Leases are now being taken and the company is presently drilling a deep well for the purpose of potential reservoir analyses.

Texas Gas Transmission Corporation. Texas Gas, has recently added an aquifer storage field to its five depleted gas field storages. Located just north of Wilfred, Ind., the Wilfred gas storage field, which originally contained some sour gas of non-commercial quantities and produced about 200,000 barrels of oil, is in the first year of operation for natural gas storage.

Gas injection was started in April 1959, and the semi-water drive field will be filled to about 2,500,000 Mcf of which half will be available for withdrawal each season. Test operations to date have proven the Silurian Reef aquifer reservoir performance satisfactory. Some evidence of corrosion by hydrogen sulfide contamination of the stored gas was experienced but has now been corrected by use of inhibitors.

OTHER AQUIFER GAS STORAGES

In addition to the United States aquifer gas storages discussed, several are located in Europe. The more important of these are:

Beynes, serving Paris, France
Vernon, serving Paris, France
Two in Germany, one at Hamburg and the other at Hanover
One in England, located east of London, under development

CONCLUSIONS

Across the nation, the use of petroleum-barren anticlinal aquifers for underground gas storage has become extremely important to the natural gas industry. They appear to be the answer to the problem of creating economical large-volume gas storage where depleted oil and gas fields are non-existent. The success of several large aquifer gas storage fields has proven them to be pioneers in the rapid development of a brand new segment of the natural gas industry.

ACKNOWLEDGMENT

From a paper presented at the American Gas Association Transmission Conference, Denver, May 25-26, 1961.

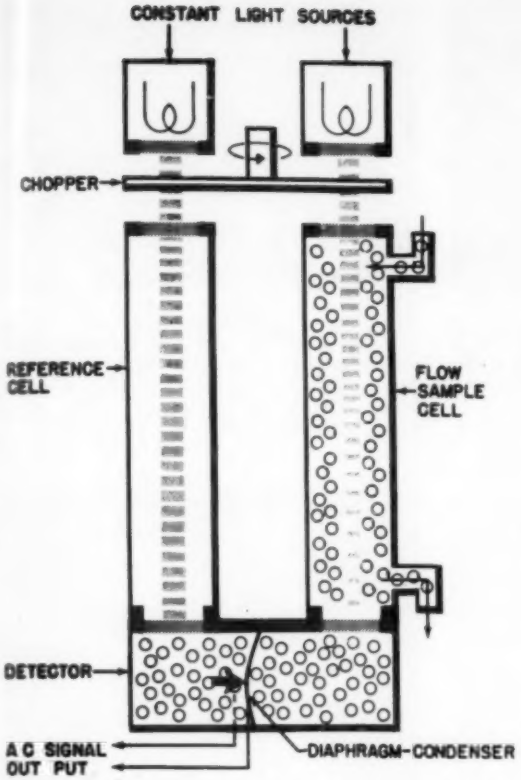


FIGURE 1—Infrared analyzer has two cells. The one at left contains nitrogen; one at right, samples of air. Detector at bottom contains methane gas. When air sample contains methane, which absorbs energy of certain infrared wave lengths, less energy reaches detector, and diaphragm moves to produce an electrical signal.

How to Make Gas Leakage Surveys for Only $5 Per Mile!

Infrared cuts the cost of leak detection by 90 percent

By P. S. Magruder, Jr., Staff Supervisor,
Southern California Gas Company, Los Angeles

BY USING a super sensitive sensing instrument—an infrared analyzer—mounted on a light pickup truck, Southern California Gas Company has been able to conduct leakage surveys on its cross-country lines for about 0.1 cent per foot. This is one-tenth of the previous cost!

The use of the infrared analyzer for mobile leak detection is not new. In 1956, E. R. Thomas of Consolidated Edison Company presented a paper on the subject to the American Gas Association. As a result, Southern California Gas purchased one of the instruments to use on an experimental basis. John D. Brady, Jr., of our company, reported on the results we obtained with the instrument to the Pacific Coast Gas Association Transmission Conference in April 1959. Thus, this paper will concern itself primarily with reporting on new developments of the past two years.

Infrared Phenomenon. In layman's terms, the infrared analyzer works like this: All hydrocarbons (as well as many other gases) will absorb heat from an infrared source and each particular gas has its own characteristic affinity for certain wave lengths within the infrared spectrum. *Thus, it is possible to identify a gas by the wave lengths of infrared rays it will absorb.*

How this phenomenon is applied to gas detection. A schematic of an infrared gas analyzer is shown in Figure 1. Two constant light sources emit infrared energy. The beams are interrupted by a motor-driven "chopper" that rotates 10 times per second. This provides intermittent—but uniform—energy sources for the two cells. The infrared beam from one of the sources passes into the reference cell (at left) which is filled with nitrogen. The other beam passes into the sample cell on the right.

The detector (just below the two cells) has two chambers filled at equal pressure with the gas which the instrument is to analyze, in this case, *meth-*

FIGURE 2— Leakage survey truck is a self-contained unit which can survey a pipe line at the rate of about five miles per hour and detect most leaks. In this instance, the fully equipped truck paid out in six months.

FIGURE 3—Bumper probe drags rubber tubes which pick up air samples at ground level. The sample air is filtered and passed into the analyzer which can detect as little as 5 parts of methane in 1 million parts of air.

FIGURE 4—Hand probe used for places the truck cannot reach. This is nothing more than a short length of copper tubing mounted on 50 feet of hose. Small diameter holes were drilled near the sealed end of the copper tubing.

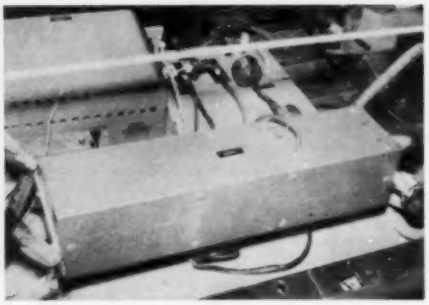


FIGURE 5—The infrared analyzer is spring mounted to reduce vibration which can reach 0.4 normal scale. However, this does not greatly interfere with methane detection.

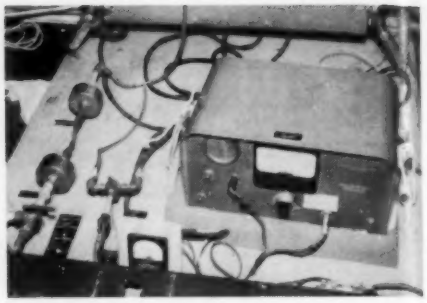


FIGURE 6—The amplifier is mounted on rubber foam to prevent damage from vibration. Two cylinders at left are dust filters; the valve at left switches from bumper probe to hand probe. The other valve controls the flow of sample air.

ane. The chambers are separated by an aluminum pressure sensitive diaphragm.

Taking Measurements. With air in the sample cell and nitrogen in the reference cell, the instrument is adjusted to produce equal pressures on each side of the diaphragm. When air containing methane is introduced in the sample cell, it absorbs energy of the wave length of the methane absorption band resulting in less energy reaching the detector chamber on the right. This results in a low pressure in the chamber on the right and the diaphragm moves in the direction of the low pressure. Movement of the diaphragm produces an electrical signal which is sent to an amplifier. The signal then actuates the recording instrument.

Sensitivity. The effectiveness of this instrument for laboratory work is well established. **It possesses a quantitative sensitivity of 5 parts per million of methane in air. This is about 1,000 times more sensitive than the usual thermo-conductivity type instruments.**

ADAPTING THE INSTRUMENT TO FIELD USE

The challenge to the pipeliner has been to adapt this sensitive laboratory type instrument to rugged field use. In this regard, our company has met with a reasonable degree of success: The principal problem was that of obtaining the air sample and getting it to the instrument.

The survey. We installed the infrared analyzer for conducting leakage surveys on a pickup truck, as shown in Figure 2. Note the generous sign, warning lights and flags mounted on the rear of this vehicle. Originally, we had set out to assemble the infrared equipment in a unitized package that could be switched from truck to truck as it was transferred from one division to the next. We found through experience, however, that shifting this equipment from one truck to another entailed considerable work. Mounting the boom, making the vacuum connections, providing extra power supply for the batteries, etc. made this plan impractical. We finally concluded that mounting the equipment in a truck to be used exclusively for leakage surveys provides the best solution to the problem. It enables you to have the necessary heavy duty generator, rheostats, meters and properly equipped truck to do a satisfactory job for infrared analyzer operation.

FIGURE 7—Recorder is mounted inside the cab. A sample of methane will show on the strip chart and cause the instrument to sound two speakers on the truck.

HOW SAMPLES ARE OBTAINED

Mechanism used for sampling the atmosphere at the surface of the ground along the pipe line is shown in Figure 3. The vacuum from the truck engine draws the sample of air through the rubber tubes, suspended from the boom, and on into the analyzer mounted in the rear of the truck. The boom is pivoted on the center of the bumper and has a rope pulley attached which can be operated on the passenger side of the vehicle to raise and lower the boom when an obstacle is encountered in the right of way. The boom may also be swung to the other side of the vehicle if conditions make that position more desirable.

Sampling Tubes. The brass header on the end of the boom is equipped with five surgical rubber hoses approximately 30-inches long. These hoses are approximately $\frac{3}{8}$ inch OD with a machine cap screw inserted into the end of the hose to seal the end and weight the end of the hose to keep it on the ground. There are six holes in each hose, one inch to three inches from the end. The holes are pierced with a hot needle, and each one is about $\frac{1}{16}$ of an inch in diameter. The hoses should be long enough to allow 3 to 5 inches of the length to drag along the ground at all times.

The first bumper probe we attempted to use for transmission line right of way surveys was a heavy boom made of 2-inch steel pipe supported on the end by a trailer dolly wheel to lift it over obstructions and maintain a uniform height above the ground. It also had a winch so it could be raised when an obstruction was reached. But the winch operation did not prove satisfactory, so we discarded this type of boom in favor of the light weight model shown here.

The hand probe installed to conduct surveys in areas where the truck cannot reach the pipe line is shown in Figure 4. It consists of approximately 50 feet of hose with a piece of copper tubing on the end. The end of the copper tubing is sealed and several small holes are drilled near the end of the tube. To survey an area which cannot be reached by the

bumper probe, the truck is stopped and the valve switched to change from bumper probe to hand probe. The hand probe can then be walked along the line. This probe is often used to confirm indications that are detected while traveling.

HOW THE ANALYZER IS MOUNTED

The analyzer is shown in the foreground of Figure 5. You'll note the four-way spring suspension used to minimize the effects of the truck's vibration. As mentioned above, the analyzer is a sensitive instrument, designed, primarily for laboratory use, and adapting it to the roll and shake of a four-wheel truck driving down the right of way was a difficult task.

Dust Filters. Air from the surface of the ground naturally has to be filtered before it enters the sensitive analyzer. To eliminate virtually all of the dust, we mounted one dust filter on the bumper probe and installed two others just ahead of the instrument. So far, this has proved satisfactory.

Annunciators. How does the crew know when the instrument finds methane? We have two speakers which produce a raspy noise whenever a sample of methane is detected. One speaker is in the amplifier cabinet; the other is located in the cab of the truck.

Power Supply. The instrument was designed to operate on 110 volt, 60 cycle AC power. This called for a converter to change the six-volt DC current from the battery into usable power. As it turned out, the analyer is very sensitive to proper voltage input. It does not operate properly below 5.6 volts or over 6 volts.

Generator. Originally, we attempted to operate off the regular truck generator, but we found it necessary to install a heavy duty 100-amp generator. This generator is connected to the box mounted on the dashboard which also houses a rheostat and volt meter. The rheostat is adjusted to maintain between 5.8 and 6 volts input to the battery at all times.

Recorder. A strip chart recording milliammeter is mounted in the cab of the truck. This instrument receives the output of the amplifier and records any indications of methane detected by the analyzer. The recorder and the infrared analyzer are capable of being calibrated to accurately record quantitative percentages of methane in the gas sample. However, we have not attempted to use the instrument in this manner and have only relied on it to show us an indication of methane. Of course the stronger the percentage of methane, the longer we will be able to see an indication on this instrument. This instrument shows only the presence of gas. Percentages of gas are obtained later when centering the leak using a conventional gas indicator.

MAKING THE SURVEY

Before starting a survey the recorder is zeroed at about 0.2 on the scale range of 1.0. Normal right of way will cause oscillation of the recorder pen up to about 0.4 of the total scale. Normally, an indication of gas will give a much stronger indication than the 0.4 due to vibration. It will normally drive to the top of the scale and hold for a few seconds and also the speaker will give a loud raspy noise. This is mentioned merely to point out that there has to be some judgment applied by the operator to be able to distinguish a gas indication from a swing of the pen caused by hitting a hard bump in the road which causes oscillation of the instrument.

Cost. Last year Southern California Gas Company surveyed over 350 miles of transmission lines at a savings of over $16,000. The following table shows the cost comparison of surveying 246 miles of line using the 25-foot interval barhole method and the infrared survey. You will note that we have performed the infrared survey for one-tenth of our normal cost.

Cost Comparison of Survey Methods

DESCRIPTION	Normal Barring Survey 25 Foot Interval	Infrared Survey Continuous
Footage of line surveyed	1,300,000 ft.	1,300,000 ft.
No. men in crew	4 men	2 men
Average footage surveyed/day	14,500 ft.	65,000 ft.
Number of days to survey line	90 days	20 days
Average distance base to job	50 miles	50 miles
Daily cost of crew and equipment	$140	$64
Total cost of survey	$12,600	$1,280
COST PER FOOT	1 cent	0.1 cent
The cost of the infrared survey equipment is as follows:		
Infrared Analyzer	.....	$2,500.00
Strip Chart Recorder	.....	375.00
Flowmeter	.....	27.00
Convertor, DC to AC	.....	152.00
Vehicle		
4-wheel drive ¾ ton pickup truck	.....	$3,000.00
Installation, body work, etc.	.....	600.00
Total	.....	$6,654.00

INFRARED SURVEY LIMITATIONS

You can see that based on last year's work we have been able to achieve a payout on this investment in less than six months. Before you get the impression that these savings can be achieved without suffering a few headaches, let me hasten to add that the infrared analyzer does have its problems and limitations. Foremost of these problems is getting the sample to the analyzer. Factors that are working against you in this area are:

1. Wind conditions
2. Soil compaction
3. Moisture content of soil
4. Moisture on surface of ground
5. Dust conditions
6. Tight pavement over pipe line
7. Limitations of sample probe design and volumetric capacity of analyzer
8. Speed of travel over pipe line.

To meet the problem of wind condition, we attempt to make our surveys in early morning hours when the wind is at its minimum. We also caution the operators to attempt to have the probe downwind of the pipe line when there are small surface breezes. The soil must be loose enough for the sample to come to the surface. We have some areas where the soil is so compact that it is impossible for the sample to get to the surface.

Moisture. We have also observed that the moisture content of the soil affects the reliability of these surveys. We have found that after a rain the soil seems to swell and acts as a deterrent to the sample getting to the surface. Moisture on the surface of the ground will tend to plug up the probes and block the flow to the analyzer.

Dust, of course, is a continuous problem; however, all that is required here is frequent cleaning of the dust filters with the operator properly trained to be able to detect when such cleaning is necessary.

Streets and Highways. We have had very little success in using the infrared analyzer over pipe lines under tight pavements. Where the pipe line

Continued on Page 53

How Weather Affects Dispatching

Few places on earth have such swift changes in temperature

By G. D. Kellam, Manager, Production and Transmission
Canadian Western Natural Gas Co., Calgary, Alta.

MOST AMERICANS think of Canada as a land of snow, ice and unremitting cold. Actually, southern Alberta has a rather mild climate with intervals of cold weather. The most unusual feature of the climate is its swift change.

For the mildness we have to thank the Chinook wind.

This is a warm wet wind which blows in from the Pacific, crossing the lower British Columbia coast and Washington state. As soon as it encounters the coastal ranges, it drops its moisture and continues on to the prairies as a warm dry wind. Probably due to some configuration of the mountains it is concentrated mainly in southern Alberta. It produces the Chinook arch, which is our token of approaching warm weather.

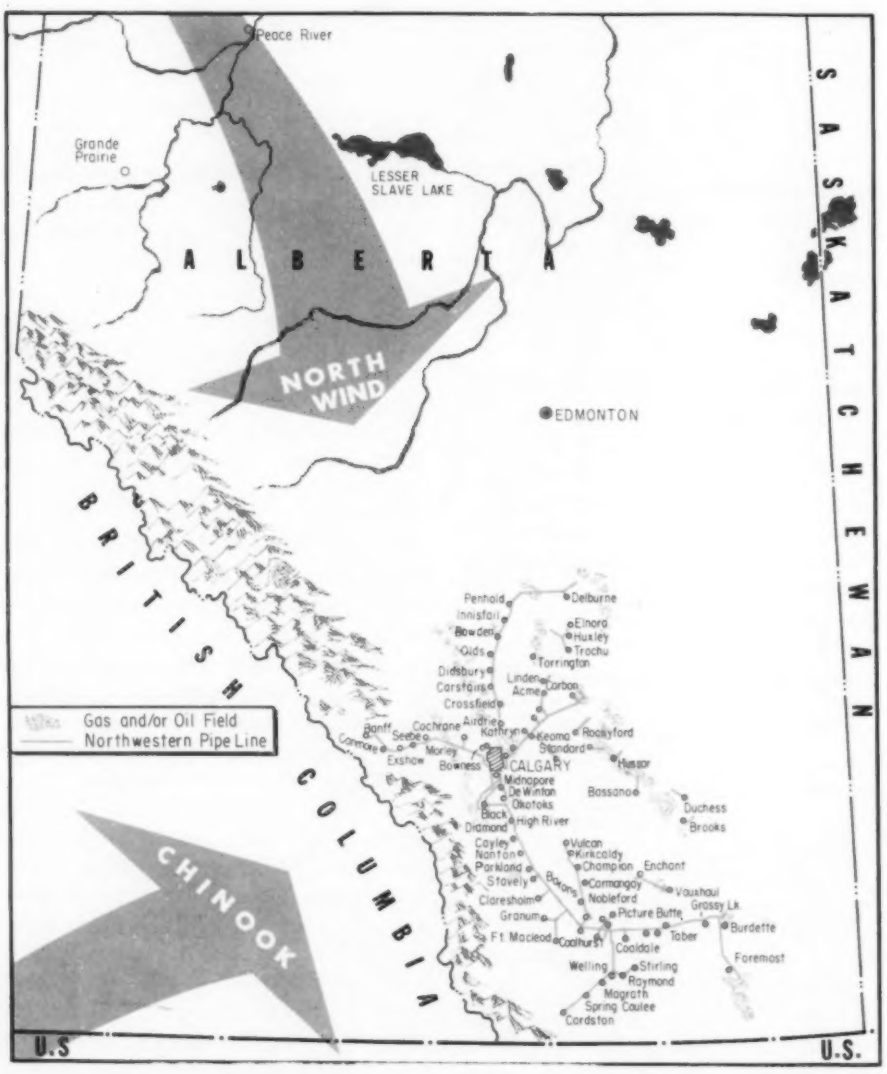


FIGURE 1—Map of Canadian Western in southern Alberta. The area has a high home heating load and this gives the company a load factor of only 39 percent. The cold winter wind from the Yukon and Alaska, may bring sub-zero temperatures to southern Alberta. But the warm Chinook wind can dispell the low temperatures in a few hours time.

Our cold weather comes from north winds from the Yukon and Alaska.

Fortunately, our meteorologists give us ample warning of the coming of both Chinooks and cold weather.

Now that we have seen our location and the sources of our climate, let us consider the effect they have on our operations.

A graph of the temperatures in downtown Calgary over a four-day period in 1956 (see Figure 2) shows what happens when a cold weather system descends on us. At 4 p.m. December 1, the temperature was a mild 57°. Overnight the temperature dropped slightly, and next morning at 11 a.m. it stood at 47°. Then the cold front arrived and the temperature fell steadily until at midnight December 2 it was 2° above zero, a drop of 4° per hour. This downward slide of the temperature continued at a slower rate all December 3, until at 9 p.m. December 4 the temperature levelled off at 19° below zero. We had been warned by the meteorologists of the coming of the cold weather, and had ample supplies of gas available. Drops in temperature such as this do not cause us any trouble because of the accuracy with which they are forecast.

Let's take a look at gas loads for this period Figure 3. At midnight December 1, our load was 104 MMcf. In the evenings and nights our loads fall off somewhat, rising again early

In Southern Alberta

in the morning, but because of the temperature fluctuations, no rise occurred until the temperature started to drop at 11 a.m. By 6 p.m. December 3, the load had increased to 213.8 million, just doubling in two days.

How the Arrival of a Chinook Affects Loads. Figure 4 shows what happens when a cold spell is interrupted by the arrival of a Chinook. On February 14, the temperature had been hovering around zero, and it was —3°F when a Chinook arrived at 6 a.m. Just 7 hours later, the temperature had risen 41°F from —3°F to 38°F, which is six degrees per hour. This rise, though sudden had been forecast, and we had no particular trouble. The gas load for this period is shown in Figure 5.

When the Weather Changes Without Warning. There are times when we have inversions. A Chinook wind will then blow right over the top of the cold air and be lost in the prairies east of us. The Chinook travels at an altitude of 1,500 to 5,000 feet. The meteorologists know it is there; and they know its temperature, but there is no way they can forecast when it will come down to ground level—if at all. Figure 6 shows effects of such a series of events occurring in a five-day period in 1952.

It is small wonder that our meteorologists sometimes adopt a defensive attitude. This capricious weather occurs fairly often—though seldom in conditions as extreme as shown here.

On the subject of weather, here is an experience of one of our executives. He had been working in the office all day, with the outside temperature about 12 below zero. He left the office, got into his car which had been parked outdoors all day, and started out to visit one of our control stations in an outlying district of the city. This station was on a hill about 200 feet higher than the central part of the city. Halfway up the hill, he encountered the forward edge of a Chinook wind. The entire surface of his car was coated with a layer of frost which formed the instant the warm air touched the cold metal and glass. He had to come to an abrupt halt and clean off his windows before he could proceed. Fortunately, this is a very rare phenomenon, but it is another of the possible side effects of a Chinook wind.

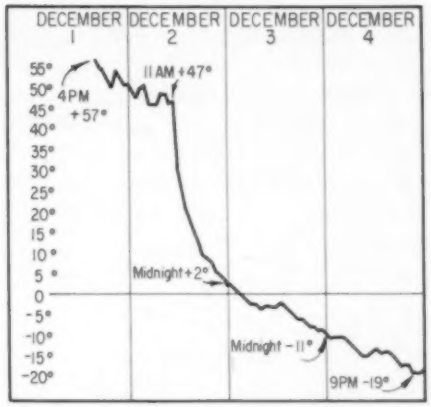


FIGURE 2—Comes the cold wind and temperatures drop: from 11 a.m. until midnight, they fell about four degrees per hour.

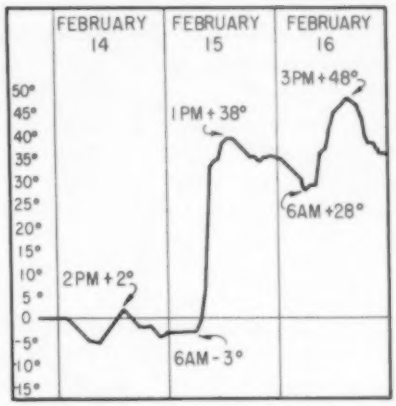


FIGURE 4—What the Chinook can do to temperatures. The rise of February 15 averaged about 6 degrees per hour!

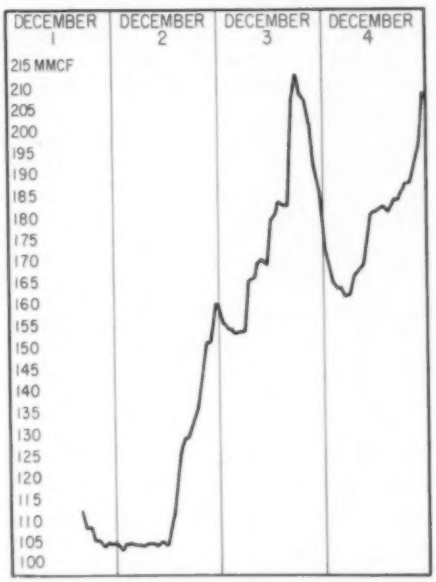


FIGURE 3—And the gas load soars. At the peak which came at 6 p.m. on December 3, the load had more than doubled!

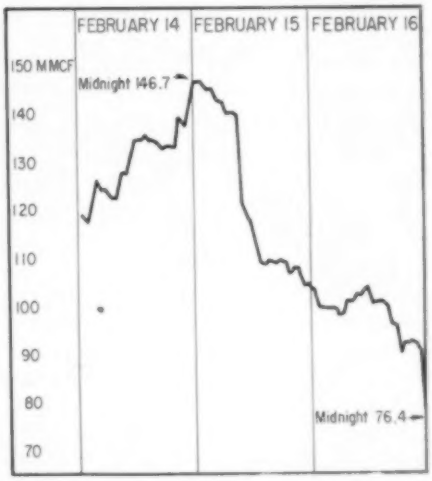


FIGURE 5—The load falls off with the arrival of the Chinook. This warming wind can usually be predicted.

Load Factor. Our load factor is 39 percent, and our problem is to match up this load factor with gas purchase contract load factors which vary from 50 to 100 percent.

We buy from three producers. One sells us 50 percent of our annual needs at a 70 percent load factor. Another 40 percent of our needs at a 50 percent load factor, and the third, 10 percent of our needs at 100 percent load factor! These load factors are based on plant output. An 80 MMcfd plant at 70 percent load fac-

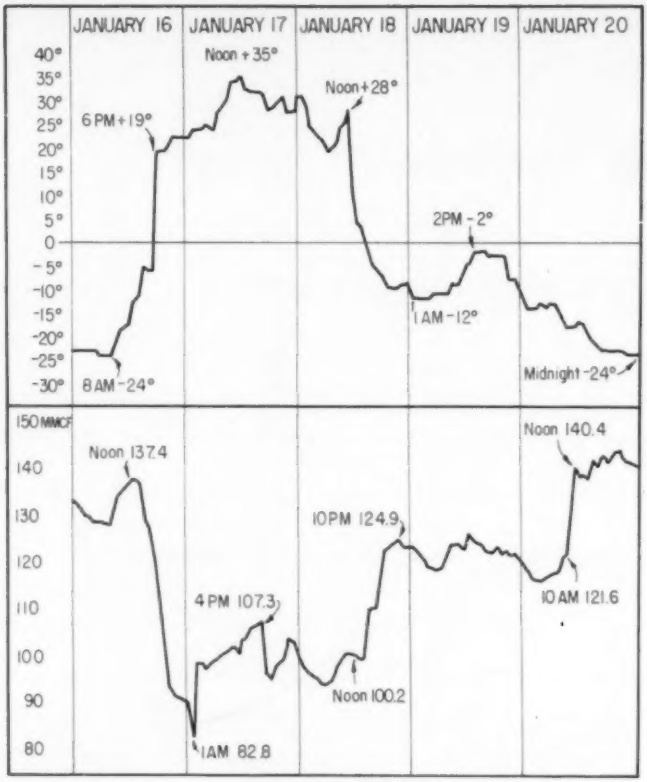


FIGURE 6—When the Chinook in the sky suddenly dips down. In this instance, the warm Chinook wind was breezing along some 4,000 feet above the ground and the temperature in downtown Calgary was —24° F! Then suddenly, the Chinook dipped down and the thermometer soared 43 degrees in 10 hours. Note how the load follows the temperature. This can partly be explained by the high home heating load of Canadian Western.

tor means that we have to take an average of 56 million per day all year. We are careful to see that this contract is based on annual quantities, and so we can vary our take from as low as 20 million in the summer up to 80 million in the winter.

The second supplier with an approximate load factor of 50 percent processes gas from an oil field. We are obligated to take all the solution gas, so our minimum take from him depends upon the oil allowables. When we need more gas, we get it from the gas cap.

Our last supplier operates a sulphur producing plant, with gas as a by-product. This raw gas is 34 percent hydrogen sulphide. We buy from him at 100 percent load factor.

We do not have any significant amount of interruptible load. Our industrial load amounts to 34 percent of our total and is at approximately 85 percent load factor, while our domestic and commercial loads, which constitute the other 66 percent of the total, are at a 30 percent load factor. Therefore anything we can do to increase our industrial base load will help our over-all load factor considerably. However, we are so close to our supply and our gas costs so much less than competing fuels that there is no advantage in an industrial customer asking for an interruptible contract. One further point in our favor is that with our own peak supply sources, we do not have any maximum demand clauses in our gas purchase contracts.

We work out what our market should be for every day of the year, assign what we think is an equitable quota to each of our suppliers, and try to come as close to that figure as possible. When the market falls short of what we must take, we make up as much of the deficit as possible by storing surplus gas in a repressuring field. This is standard procedure. In winter, of course, we withdraw from this storage to meet peak demands. Recently, to insure adequate peak load supplies, we purchased a sweet gas field and are now developing it. It has approximately 1,300 psi formation pressure, and when this pressure has been drawn down to 1,000 psi, we plan on repressuring there also.

On the average year we manage to come out even. Last year, however, was a very warm year and we fell behind on all our quotas. We will have a substantial deficiency payment to make.

Communications. When our company started in 1912, we built our own telephone system, with a line into every gas field and town we served. For standby, we connected into the Alberta government telephones.

In winter blizzards, however, all overhead lines are in danger of severe damage; **Recently we have been rebuilding our telephone system using rural electrification conductor instead of telephone wire. This conductor is steel cored aluminum cable and is immensely strong. We have had no service interruptions on our telephone line since replacing copper wire with this conductor.**

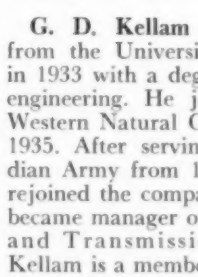
We also have installed short wave radio, and it is set up to carry telemetering signals in addition to voice signals.

We maintain our own radio and telephone repair crews. This gives us greater reliability.

In conclusion, it should be pointed out, that the reason for our severe load changes and poor load factor can be charged to the saturation of house heating. But this is the premium load and we are lucky to have the opportunity to supply it.

ACKNOWLEDGMENT

From a paper presented at the AGA Transmission Conference, Denver, May 25-26, 1961.



About the Author

G. D. Kellam was graduated from the University of Manitoba in 1933 with a degree in electrical engineering. He joined Canadian Western Natural Gas Co., Ltd., in 1935. After serving in the Canadian Army from 1939 to 1945, he rejoined the company. In 1957, he became manager of the Production and Transmission Department. Kellam is a member of the NACE, AGA, Canadian Gas Association, PCGA and Association of Professional Engineers of Alberta.

Digest: Engineering Aspects of Photogrammetry

Its capabilities and limitations

By B. Austin Barry, F.S.C.
Associate Professor,
Civil Engineering,
Manhattan College, New York

SOME ENGINEERS are unaware of the existence of photogrammetry. Others, are wary of its engineering capability. To understand its basic principles, however, is to perceive its value in engineering planning and design—particularly in cross-country pipelining—and also to acquire the minimum confidence necessary to use it wisely to save time and dollars.

Photography is the prime ingredient in photogrammetry; and to enable us to make accurate and intelligible measurements on photographs, the very finest cameras, films, emulsions, lenses and shutters must be used. Airplanes, of course, furnish the overhead camera platform, flying from 1,000 to 60,000 feet (and even higher) for aerial surveying photography.

Are photographs maps? Once a vertical photograph is taken and enlarged, can it be used as a map? The answer is unqualifiedly, No! Let us see why by looking into some interesting optical geometry.

Scale of the Photographs. A vertical (i.e. camera-axis vertical) photograph bears a similarity to the ground it pictures as seen in Figure 1. The line diagram (Figure 2) shows line ab to be proportionately smaller in the photo than the line AB on the ground. The reduction ratio is f/(H-h), as can be seen:

$$\frac{ab}{AB} = \frac{f}{H\text{-}h}$$

(This ratio is the "scale" of the photograph.)
Thus if the focal distance is 6 inches, the ground is at elevation 5,000 feet, and the plane is flying at 17,000 feet, then the scale is 1 in. = 2,000 ft. Thus a 500-foot line on the ground will scale ¼ inch on the photo.

For a more reliable photo scale, measure the ground distance *AB* and the photo distance *ab*. But note that even with level terrain, the scale will vary according to the distance from the center of the photograph.

Rolling Terrain. Consider a rolling, hilly or mountainous terrain as shown in Figure 3 and see what becomes of our neat geometric similarity. All notion of scale seems valueless, because it varies from place to place on the photo by reason of difference in elevation. In Figure 4, scale in the region of *A* is smaller than in the region of *B* because of this difference.

Distortions. Terrain closer to the camera (at higher elevation) appears larger than a bit of terrain farther away. Also, a higher ground point appears to be farther from the photo center than a lower ground point, all other things being equal. Thus, ground elevation is an important factor in photo distortions.

Radial Displacement. A camera presents a perspective view. Note in Figures 5 and 7 that the top of a hill is displaced radially outward, and a valley radially inward. No displacement occurs directly beneath the camera. It is easy to visualize this by imagining a flagpole or building photographed from nearly overhead, but not directly overhead. The top will be farther from the center than the base. A comparison of Figures 6 and 7 points up this basic principle of radial displacement.

Differences in Focal Length of Lens. In Figure 3 two different cameras—one with a focal length of 6 inches, the other 12 inches produce the same scale, 1 inch = 200 feet., yet one plane is twice the height of the other.

STEREOSCOPIC VISION FROM PHOTOGRAPHS

By pairing up two photographs of the same area taken from two vantage points above the ground, we enable

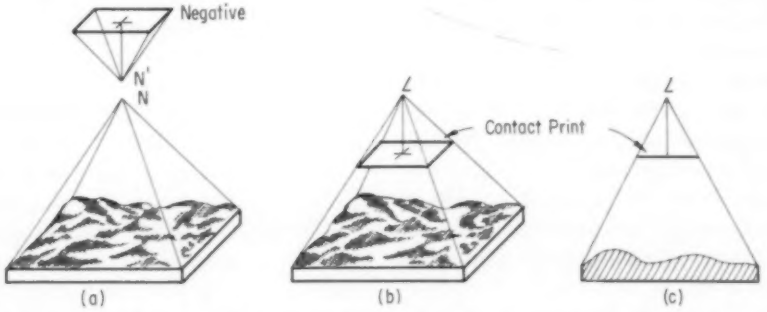


FIGURE 1—Relationship of photo and ground varies widely according to terrain and altitude of the camera. A single photograph may have many errors in it.

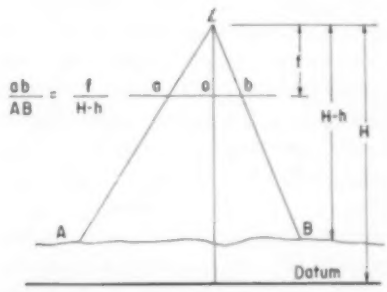


FIGURE 2—Scale Relationship. Focal length of lens—say 6 inches—is proportionate to height of camera above ground pictured. H-h, say 12,000 feet. Thus, scale in photograph will be one inch = 2,000 feet.

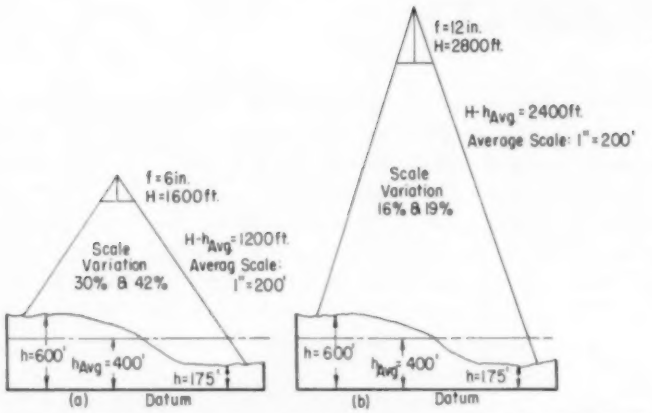


FIGURE 3—Two different cameras produce same scale. One inch = 200 feet. Camera at right has twice focal length as one at left, but it is also twice as high. Scale in each photograph will vary according to elevation.

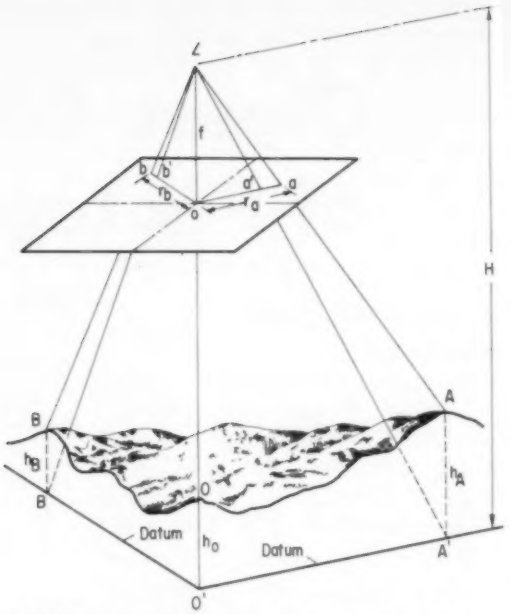


FIGURE 5—Radial displacement from topographic relief. Hill is displaced radially outward; valley is displaced inward.

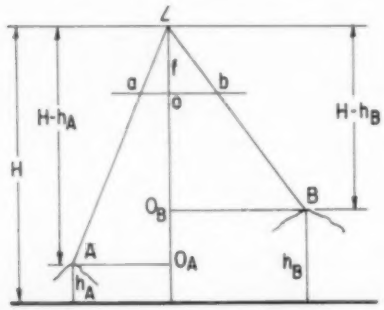


FIGURE 4—Two different scales in a single photo results from the variation in elevation on the ground.

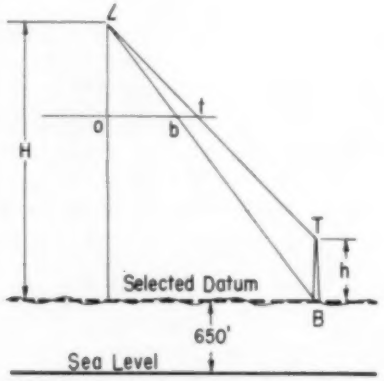


FIGURE 6—Explanation of radial displacement. Note that the top of the flagpole will print on the photograph farther out from the center than its base.

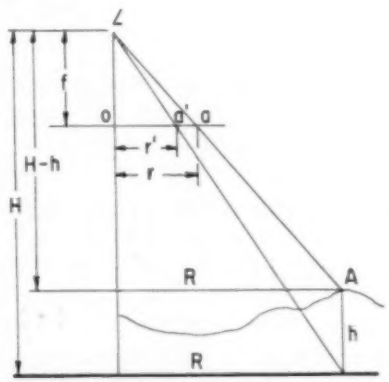


FIGURE 7—Parallax (aa') from topographic relief. Actually parallax is of great value to photogrammest because it enables him to measure height with great accuracy using stereoscopic means.

the use of stereoscopic vision. The terrain elevation differences become dramatically evident (because in this case greatly exaggerated). Figure 8 shows how the eyes perceive the distinction between near and far, and in the case of two vertical photos, between higher and lower ground.

By proper instrumentation the photogrammetrist from a pair of overlapping photos can use the "distortion" of a hill (i.e. its displacement radially outward) to ascertain the height of the hill above a point in the valley.

The displacement of features, called "topographic relief displacement" provides the fundamental effect required to achieve stereoscopic vision when a pair of overlapping photographs is viewed with a stereoscope and a device for measuring photo displacement or parallax, the parallax bar. Stereo-projection (as opposed to stereo-viewing) equipment is generally used, and extremely accurate elevations can be obtained by fairly direct measurement.

Inherent in stereoscopic viewing is a reversing of the photo distortion or displacement such that the rays of light get re-projected back into space where they belong—instead of flat on the plane of the photograph. By simply intercepting these rays properly (as in Figure 9, ray *a* from photo number 1 and its counterpart ray *a'* from photo number 2), the true location in *x*, *y*, and *z* of all photo images can be discovered. By plotting a given point at once on the *xy* plane (the map table) and noting its elevation, the terrain can be mapped point by point. The tracing table is seen to intercept the projected rays, and directly beneath, the imaged detail is plotted.

A schematic view of the complete process from photographing to projecting is shown in Figure 10, the diapositive being simply a smaller positive glass transparency used in the projector.

CONTROLLING THE SPATIAL MODEL

What about the scale of the map and how do we know the elevations?

Map scale is fixed by setting the pair of projectors the correct distance apart, adjusting them to project their rays in coordination upon the tracing table as it is moved around on the map surface. Essentially two ground points whose x- and y-coordinates are known are used to control the spacing

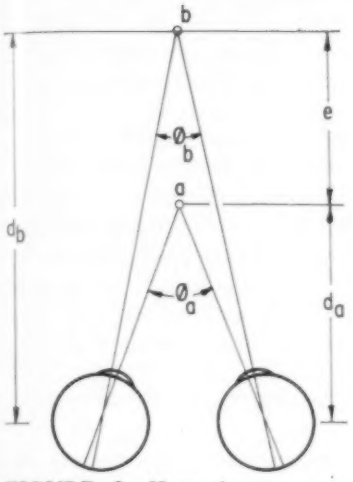


FIGURE 8—How the eyes use parallax for depth perception.

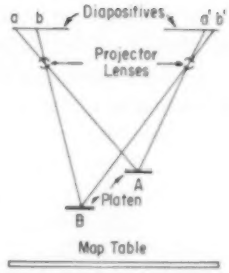


FIGURE 9—Re-projected rays properly intercepted in space enables us to prepare relief maps with accurate elevations.

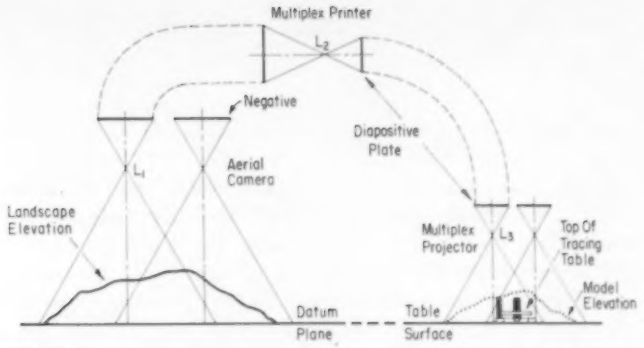


FIGURE 10—Schematic view of process starting with the photographs and ending with the tracing table.

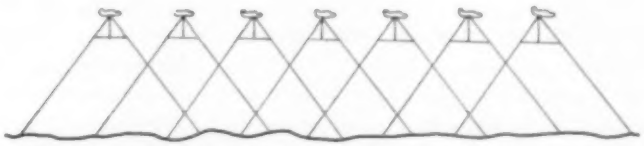


FIGURE 11—Overlapping in the direction of flight is usually 60 percent.

of the projectors and form a true spatial model of the terrain to the desired scale. Elevation controls are used as well to eliminate tilt in the model.

The "ground control" needed to fix the map to true scale must be obtained by field survey operations familiar to all. Somewhere in the area of the photographs there must be visible a number of points whose coordinates have been ascertained; somewhere some elevations also must be known.

There exists a fair degree of latitude in selecting control points on the ground, and often the most convenient points—and the most useful to the stereo-operator—are found in the fringe areas of the photos. Topographic mapping would normally demand one pair of horizontal control points and four vertical control points in each stereo pair (or model). However, horizontal control and, to a limited extent, vertical control may be extended by aerotriangulation, or stereotriangulation, or bridging. This is the reason for more than two projectors on such a machine. By its use a reduction in the amount of ground control is possible.

COMPILING THE TOPOGRAPHIC MAP

The topographic map is compiled onto a map sheet gridded to scale, the compilation being done by continued utilization of the stereo technique. From simple devices like the stereoscope and parallex bar, the Stereocomparagraph, and the Stereotope to larger equipment like the Kelsh Plotter, the Multiplex or Balplex Projector, and the Stereoplanigraph, the basic principle of stereo enables the plotting of all photo images in three dimensions. Cultural and drainage details, roads, buildings, rivers, lakes, etc., are properly located on the map manuscript; then elevation information by contours and/or by spot elevations is placed thereon to provide the desired terrain representation. The map is then ready for the planning and/or the design stage. Only this can be called a *map,* for it is a "reconstituted" scale image of the terrain, free from radial displacement and/or distortion, with all culture and topography plotted in correct orthographic position.

The foregoing brief explanation of photogrammetric principles is important background to the proper understanding of maps and mapping for pipe line design.

ENGINEERING DESIGN OF PIPE LINES

Selecting the route. Any surveying for a pipe line must discover an economical route, show property lines and other crossings and provide information important to construction. After initial studies of existing maps, routes are narrowed down, and the desired areas are photographed to a suitable scale for closer scrutiny and actual route selection. Such a photo scale might well be 1 inch = 1000 or 2,000 feet thus furnishing a strip from 2 to 3½ miles wide for stereoscopic study.

From a study of the 9 inch by 9 inch photographs, the entire width or often a narrower band can be selected for mapping at a scale of 1 inch = 200 feet with 5-foot contours or 1 inch = 400 feet with 5-foot or 10-foot contours, or even at 1 inch = 1,000 feet.

Obviously, no fixed rule on scale can be cited here, since demands will vary and topography differs widely from one area of the country to another. There are also instances where spending money for additional high-level photography will result in savings by faciliting bridging, or where additional low-level photography will facilitate crossing or terminal design or urban-area location. Such determination can best be made by the photogrammetric consultants as the study proceeds.

Once the maps come from the stereoplotting machines, and even during the time they are being worked up into final form, the pipe line locating engineers are busy at work selecting the location in detail. They have the advantage of viewing the photographs stereoscopically while they work, by use of even a simple pocket stereoscope, thus having the terrain virtually before them in three-dimensional form at all times. The photointerpreters are able to furnish them information as needed and point out areas that should be studied more

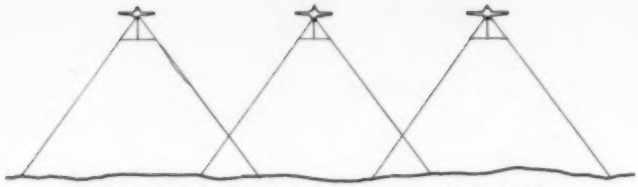


FIGURE 12—Side lap of 30 percent is desirable.

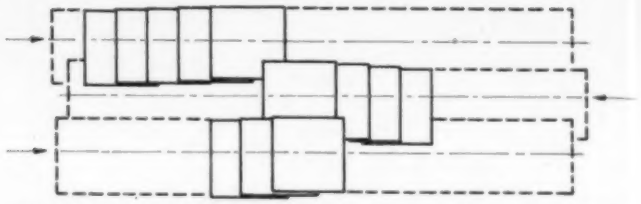


FIGURE 13—Photo lay-down showing over lap and side lap.

closely on the ground.

The exact procedure may vary from job to job, but the essentials are the same: the line is located in the most feasible position for the given project without having to "walk the line" foot by foot.

Pointers on Using Photogrammetry

1. To provide stereo coverage of an area the photos are taken with 60 percent overlap in the flight direction Figure 11, and 30 percent side lap Figure 12. The combination of the two overlaps is seen in Figure 13. Normally, the adjacent flight strips are matched by this 30 percent side lap, but in a strip-mapping project (as for a pipe line) the operation is frequently done by a single flight line.

2. Matching photographs by the pictured detail and mounting them together to form a mosaic can be helpful at times, but for reasons that should be obvious, a photo-mosaic should not be regarded as a map. Serious property problems have arisen through failure to recognize this limitation in the use of aerial photographs. There are, incidentally, certain new commercial techniques becoming available that will render photo-mosaics into orthographic (true) photo-maps where it is deemed to be desirable, and such photo-mosaics may one day become quite common as maps—provided people can learn to read and use them. But until and unless a means is employed to eliminate perspective distortion from the photos, it must be emphasized that while a simple montage of photographs is often extremely useful for illustrative, study, and reference purposes, it is not a map and its use as a map can lead to embarrassment or even to disaster.

3. Individual photos, available to the client during the mapping and planning, permit an invaluable adjunct operation: the leisurely study of the terrain. A stereoscope permits qualitative topographic evaluation at considerable magnification. Old property lines can easily be spotted, and selection of right-of-way to avoid complications with topography or unsympathetic land-owners can be effected.

4. Much can be said about the value of photo-interpretation, now gaining increasing recognition as a valuable engineering art (and science) allied to photogrammetry. It can be provided as an adjunct service by the group providing the mapping, and it is worth investigating. Good interpretation can aid immeasurably in routing a pipe line through less valuable timber or less dense rock, in spotting access possibilities for construction and maintenance that might otherwise be easily missed, or in making drainage, soils, and geological analyses. An experienced photointerpreter is able also to adduce mysterious conclusions from photos, often spotting unsuspected soggy terrain, a granite rock stratum lurking just beneath the surface, possibly a geological fault line, a valuable gravel deposit, or perhaps even a belligerent farmer.

5. One feature of photogrammetric surveying that pleases those engaged in route location is invariably the freedom they enjoy in selecting the route and even designing the project to completion without tipping their hand as to its final location. This can be done because the ground-control surveys need not be made particularly near the right-of-way and a passing airplane will usually arouse no suspicion. The right-of-way procurement can be handled in a smooth manner prior to stake-out through standardized strip maps and annotated photographs without extensive time spent in working up unneccessary abstracts, securing options, etc. A photograph in hand will frequently be a persuasive factor in securing a right-of-way or easement from a property owner, for he can then be more easily dissuaded from his fears or suspicions.

6. By the same token, photography flown before, during, and after construction will provide irrefutable records of progress, damage, and restoration. Photographs can be used directly as maintenance records, and the original strip map is invaluable as the base for the final map for survey, easement, and right-of-way records. Both maps and photos are continually available for maintenance and records virtually from the time the first earth is turned.

It is hoped that photogrammetry will now be something less mysterious and become instead a familiar tool for the pipe line designer.

CONCLUSION

A final important counsel that cannot be left unsaid is that the practice of photogrammetric topographic mapping is professional engineering, involving responsibility on the part of an individual for the final result attained. The photogrammetric engineer, having under him a corps of technicians to fly and photograph, to reproduce prints and diapositives free from tilt and aberration, to survey and utilize ground points for control, and to produce for the client an accurate and appropriate map, does in the process exercise continuous engineering judgment to assure the integrity of the final product.

Each job and each map must be engineered to serve a particular purpose; each client must be counseled with respect to a particular need. It is obvious that photogrammetric engineering service must be contracted on a negotiation basis in a professional manner and not by competitive-price bidding. This is in accord with the defined policy of the American Society of Civil Engineers, a policy designed to safeguard the client in this very important engineering service.

It is hoped that this present effort will introduce some to and enlighten others on surveying by photogrammetry, the twentieth-century tool of the engineer. Without question the wealth of data which can be reliably

and economically obtained through use of a carefully integrated photogrammetric program will result in time-saving and better decisions by pipe line engineers in the selection of their routes.

There follows a list of references which may well be perused by those concerned with this endeavor. Interesting facets not covered in this presentation can be found therein, answering questions that may still be unanswered.

ACKNOWLEDGMENT

Use of illustrative material furnished by the following is acknowledged:

International Textbook Company, Scranton, Pa. for illustrations from the textbook "Photogrammetry" by F. Moffitt, Figures 1, 3, 4, 5, 6, 7, 8, 9, 11, 12, and 13.

Aero Service Corporation, Photogrammetric Engineers, Philadelphia, Pa. for Fig. 2.

Bausch & Lomb, Incorporated, Rochester, N. Y. for Fig. 10.

From a paper presented at the 1961 American Gas Association Operating Section Conference, May 25 to 26, Denver.

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About the Author

B. A. Barry, F.C.S., is a graduate of Catholic University and holds engineering degrees from Rensselaer Polytechnic Institute and New York University. He is an associate professor and presently acting head of the Civil Engineering Department at Manhattan College, where he has taught since 1942. Brother Barry also is president of the American Congress on Surveying and Mapping and a member of the American Society of Photogrammetry and the ASCE. He has written extensively on surveying and photogrammetry and co-authored with R. C. Brinker "Noteforms for Surveying Measurements." He is a member of the American Society for Engineering Education, the Society of Military Engineers, Chi Epsilon, Sigma Xi and a Brother of the Christian Schools; he has also acted as consultant in the development of a digital computer for surveying computation for the Lockheed Electronics Company.

How to Make Gas Leakage Surveys for Only $5 Per Mile!

Continued from Page 45

is located close to the shoulder of the road or adjacent to a parkway, we have had success in running the probe along the shoulder of the road or along the parkway in order to pick up leakage.

Speed. We have found that the surveys are more reliable if the speed of the vehicle is kept at less than 5 miles per hour. Other companies have reported success at greater speeds. We have picked up indications at speeds of 20 miles per hour; however, we feel that this is exceptional rather than a general rule.

Other limiting factors are the effect of vibration on the instrument. This not only affects the operation of the analyzer itself but of the indication shown on the recorder. Again we have tried to overcome this limitation by improved mountings and in training the operators to be able to distinguish the difference between false and valid indications. Field maintenance of the instrument has also created problems. Southern California Gas Company has developed training manuals and instruction programs so that pipe line personnel in our divisions can operate and maintain this equipment. The problems are not only in the area of electronic maintenance but also in mechanical maintenance such as cleaning dust filters, keeping the probe, tubes and sample chamber free of dust.

Correlation With Other Tests. Another problem that gives the pipe line operator a headache is the lack of correlation that you are able to achieve in running over a given area with the infrared analyzer and going over the same area with the barring survey. We have found that there are indications that we pick up on the barring survey that we have missed on the infrared and vice versa. All of this, I feel, is related to the problem of getting the sample to the surface of the ground. If there is a crack in the surface or the ground is porous, the infrared will pick it up where it may be between the intervals of your barring surveys and therefore miss it. We haven't found, however, that there have been any serious leaks that we have missed with the infrared analyzer.

To overcome the possibility of missing small leak indications in an area where a strong indication is found, the repair crew bars for about 500 yards on each side of the leak to see if there are any minor leaks in the area. We find that most of our leakage does occur in rather limited areas rather than the over-all length of the pipe line.

Improving the Technique. Number one on our list of future improvements is to improve on our sampling technique. This will include experimenting with different types of sample probes, increasing the flow of sample to the analyzer and stabilizing the rate of flow. We also plan to improve our mounting system for both the analyzer unit and the recorder to further decrease the effect of vibration.

In conclusion, I feel that the infrared is giving us reasonably reliable results comparable to barring in open country and at a considerable savings. I do not feel that this method will replace barring, particularly in leakage centering work or where heavy pavement is present; but recognizing its limitations and using judgment in its application, it has proven to be a sound investment.

ACKNOWLEDGMENT

From a paper presented before the American Gas Association Transmission Conference, Denver, May 25-26, 1961.

About the Author

Philip S. Magruder, Jr., joined Southern California Gas Company following his graduation from the University of Southern California 13 years ago. Most of this time has been spent in the Transmission Department where he is supervisor of the operating staff, specializing in both operating and maintenance problems.

PART 2

Trunkline Reports on Low-Cost

In a certain velocity range, when sharp sand is blown through a line, it will clean and polish the pipe walls to effect an increase in efficiency

By Adrian W. McAnneny, Manager for Engineering Planning

and Lester C. Sullivan, Supervising Engineer, Research & Development
Trunkline Gas Company, Houston

IN LAST MONTH'S PIPE LINE INDUSTRY, we discussed the technique and preliminary test results of internally sandblasting pipe lines using natural gas as motive power to drive sharp sand through a section of pipe to clean and polish its internal surface. Using test results from a section of four-inch line, we extrapolated to predict the results we could expect with a 26-inch line. Our next step was to actually try the new technique on a section of 26-inch line.

SAND BLAST TESTS ON 26-INCH LINE

Transmission Factors. Test results on the 4-inch line and the extrapolation of data to a 26-inch line indicated that such a line could be satisfactorily sandblasted and that improvements in transmission factors in the order of 10-16 percent could be reasonably anticipated. In view of these studies the decision was made to sandblast a 7.9 mile section of 26-inch pipe. The section selected was an unusually straight and level line in the Mississippi Delta. It had a relatively low transmission factor of about 19.5 at a flow of about 400 MMSCFD, or a Reynolds number of about 16 million. This corresponds to an "E" factor of about 86 percent using the Panhandle A flow equation.

Pigging vs. Sandblasting. In an effort to determine the relative value of "pigging" and sandblasting it was decided to run pigs and make flow tests until no significant increase in transmission factor was observed. Upon completion of this "pigging" operation the line would be sandblasted and flow tests re-run to determine whether or not any improvement in transmission factor could be obtained by utilizing this cleaning procedure.

Results of Pigging. Figure 3 gives a plot of the results of these tests. Also shown on this sheet is the curve for smooth pipe flow and a line showing the predicted results based on the tests made on the 4-inch line.

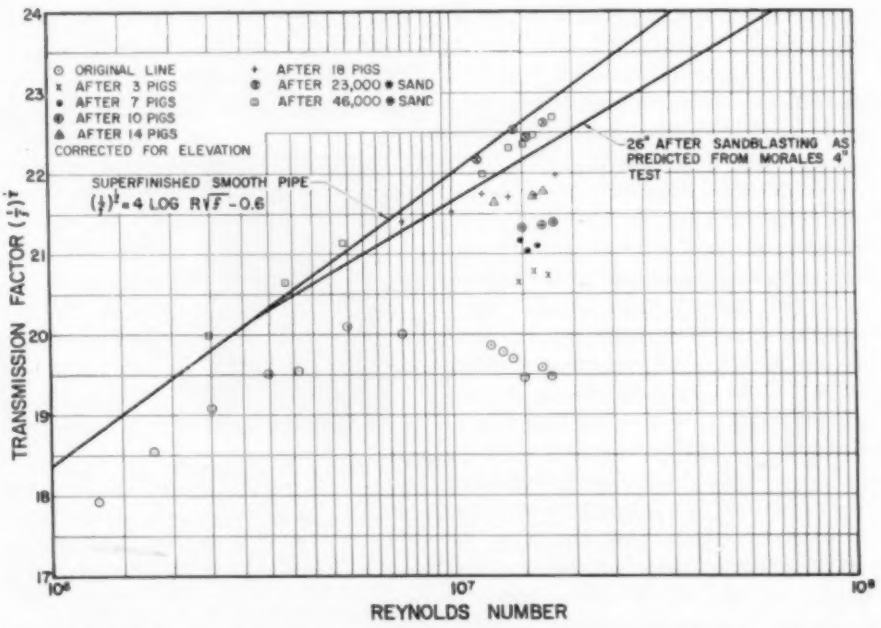

FIGURE 3—Test results: Pigging compared with sandblasting of 7.9 miles of 26-inch 5/16-inch w.t. pipe. Pigs were run until no improvement could be detected between pigs; then the line was sandblasted. One curve shows predicted results as extrapolated from 4-inch tests; the other shows smooth pipe flow.

Transmission Factor Increase. Pigging the line gave an increase in transmission factor at a Reynolds number of 17 million from 19.5 to about 21.8, or an increase of almost 12 percent. This is equivalent to an "E factor" of 97 percent. It is interesting to note that successive piggings caused a reversal in slope of the curve and caused the transmission factor to increase as Reynolds number increased.

EDITOR'S NOTE: Equations 12 and 13 in Part 1 were derived from data obtained on a 4-inch diameter pipe test and extrapolated to 26-inch diameter pipe. Equations 14 and 15 in this part of the article are a refinement of equations 12 and 13 and are based on actual field data obtained on a 26-inch diameter pipe line test.

Sandblasting That Increases Gas Flow!

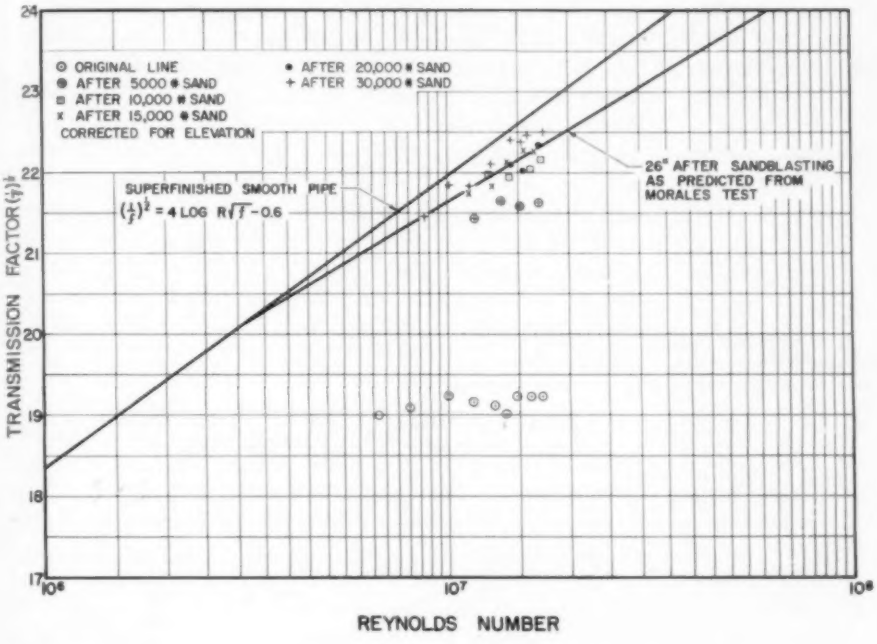

FIGURE 4—Plot of transmission factor vs. Reynolds number for various amounts of sand injected in 9.1 miles of 26-inch 5/16-inch w.t. pipe.

Sandblasting the 26-Inch. The line was then sandblasted with 23,000 pounds of sand and flow tests were repeated. The transmission factor increased to 22.6 (E factor = 101.5) or an additional increase of about 4 percent for an over-all increase of 16 percent. Transmission factors obtained from flow tests run after the sandblasting correlate extremely well with the predicted values based on the 4-inch tests. They were actually about one percent higher than predicted.

Surface roughness measurements and visual inspection indicated that the pipe was progressively smoother from the point of sand inlet to the pipe to the point of sand exit from the pipe. It was decided to sandblast again with the same quantity of sand, but from the opposite direction. The results indicate that there was no significant change in transmission factor due to the second blast with the additional 23,000 lbs. of sand. It is quite apparent that the additional sand produced no significant change in transmission factor, although the surface roughness was decreased.

EFFECTS DUE TO POUNDS OF SAND BLOWN

A second series of tests were then performed on a 9.1 mile section of 26-inch pipe to determine the variation of transmission factor, surface roughness and pipe wall erosion at a field bend with the quantity of sand throughput. This test section was also very straight and level. One "squeegee" was run through this line prior to sandblasting to remove any liquids which might have been in the line. The squeegee came out dry indicating that there were no liquids in the line. Sand was blasted through in increments of 5,000 lbs., after which measurements were made of wall thickness at the test field bend, surface roughness measurements were made at five locations along the length of the pipe, and flow tests were run to determine the change in transmission factor. After 20,000 pounds of sand had been used in this manner and there was no significant change in transmission factor, the direction of sandblasting was reversed and an additional 10,000 lbs. of sand was run.

Effectiveness. Figure 4 is a plot of transmission factor versus Reynolds number for the various amounts of sand injected. The major portion of the increase was obtained from the first 5,000 lbs. increment of sand. A small but definite increase in transmission factor was obtained when the direction of sandblasting was reversed. Again the transmission factors were about one percent higher than predicted. Figure 5 is a plot of transmission factor versus

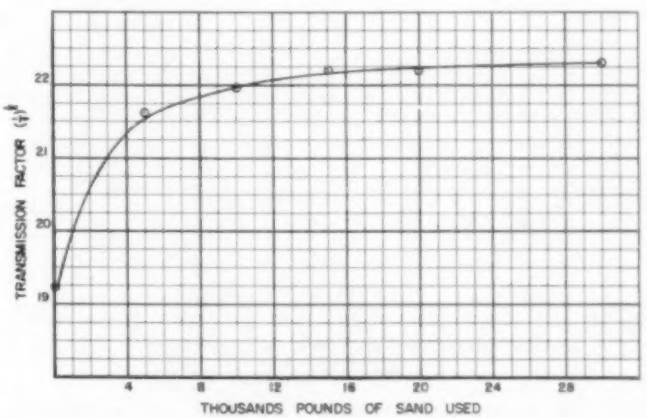

FIGURE 5—A plot of transmission factor vs. pounds of sand for a Reynolds number of 15 million corresponding to a flow of 375 MMcfd.

pounds of sand for a Reynolds number corresponding to a flow of 375 MMSCFD. This curve clearly indicates the effectiveness of the initial sandblast.

Pipe Wall Roughness. Figure 6 is a plot of the pipe roughness versus pounds of sand. This roughness is measured as an arithmetical average, and is expressed here as the average of all readings taken at each of five locations down the pipe line at the end of each sand blast. It would be necessary to know the form factor of the roughness wave shape to obtain the peak to peak absolute roughness. Obviously this is not known, so it is the trend rather than the absolute roughness which is important here.

Transmission Factor vs. Surface Roughness. Figure 7 shows a plot of transmission factor versus surface roughness for a Reynolds number of 15 million. It is apparent that a further decrease in surface roughness will not result in any appreciable increase in transmission factor at this Reynolds number.

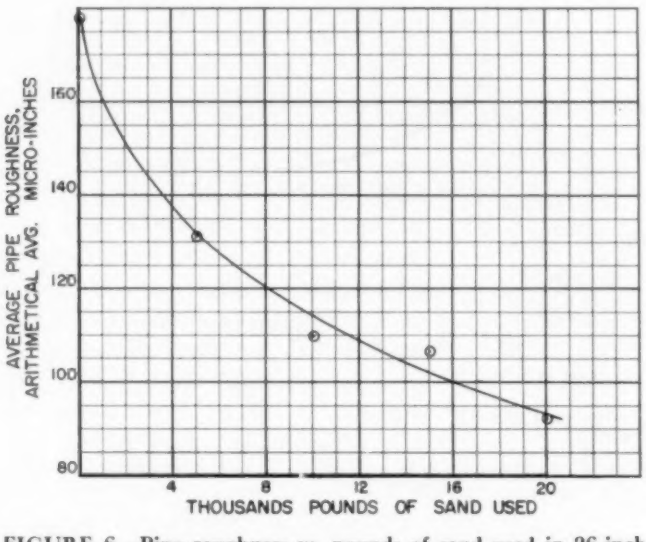

FIGURE 6—Pipe roughness vs. pounds of sand used in 26-inch pipe. The roughness is measured as an arithmetical average for each of five locations down the pipe line at the end of each sandblast.

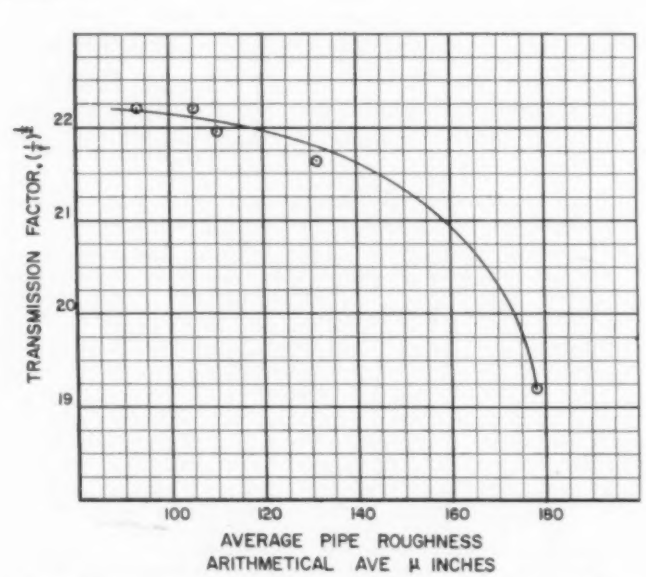

FIGURE 7—Transmission factor vs. average surface roughness for a Reynolds number of 15 million, corresponding to a flow of 375 MMcfd. It is apparent that a further decrease in surface roughness will not result in any appreciable increase in transmission factor at this Reynolds number.

Pipe Wall Erosion in 26-inch. The effects of the number of pounds of sand that have been blown on the erosion rate is shown on Figure 8. This is a straight line function as would be expected. This indicates that the rate of wall erosion for a 26-inch pipe bend of 1½ degree per pipe diameter will be about one mil per 15,000 lbs. of sand. The method of measuring wall erosion utilized a sonic device developed by the AGA-SGA Council for Non-destructive Inspection of Steel Pipe at the Southwest Research Institute in San Antonio, Texas. This device was developed in the normal course of the research program and was field tested for the first time on this series of tests. Upon completion of all sandblasting tests the test bend was sent to the laboratory where the final wall thickness at each field tested points was checked with micrometers. The agreement between the two methods of measurement was excellent. These tests indicate that erosion due to a normal sandblast cleaning will be insignificant.

SANDBLASTING A HIGH TRANSMISSION FACTOR 26-INCH LINE

In view of the favorable results obtained from the above tests the decision was made to sandblast a section of 26-inch pipe which had a relatively high transmission factor. A 10.1 mile section of pipe was selected which had a transmission factor of about 20.5, (E factor = 94 percent) which was the highest anywhere in the system.

Effects of Oil. While the equipment was being set up for these tests it was noted that the surface of this section of pipe was extremely oily. Surface roughness measurements were in the order of 130 micro-inches which is very low compared to previous initial surface measurements made on other installed pipe which had ranged from 180-250 micro-inches.

The effluent sand from this section was oily and the oil was still visible on the pipe surface after 25,000 lbs.

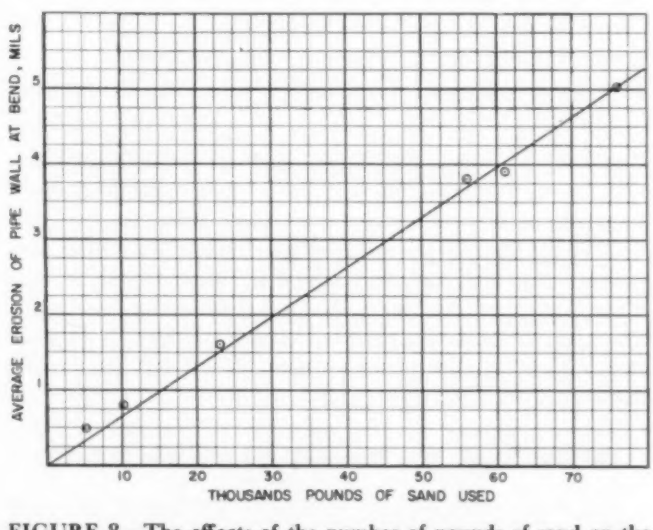

FIGURE 8—The effects of the number of pounds of sand on the erosion rate. For bend with curvature of 1½ degrees per pipe diameter, the erosion is about one mil per 15,000 pounds of sand.

of sand had been blown through the line. An additional 20,000 lbs. of sand was then used and about the last half of this sand came out clean. Here then is a section of pipe which required about 45,000 lbs. of sand whereas earlier tests indicated that 25,000 lbs. should be adequate. This points out that until more experience is obtained on all varieties of internal pipe surface conditions, pipe diameters and lengths, no one set cleaning procedure can be expected to produce uniform results.

Results. It was suspected that the inlet end of the pipe had not been adequately cleaned, so simultaneous tests were made on the first 1.7 miles and the last 8.4 miles of this section. The improvement obtained in transmission factor on the first section was only 2.4 percent compared to 8.3 percent on the 8.4 mile section, confirming that this section of pipe had not been adequately cleaned. Figure 9 is a plot of the results of these tests. These test points clearly show this difference in the reduction of surface roughness between the two sections of pipe.

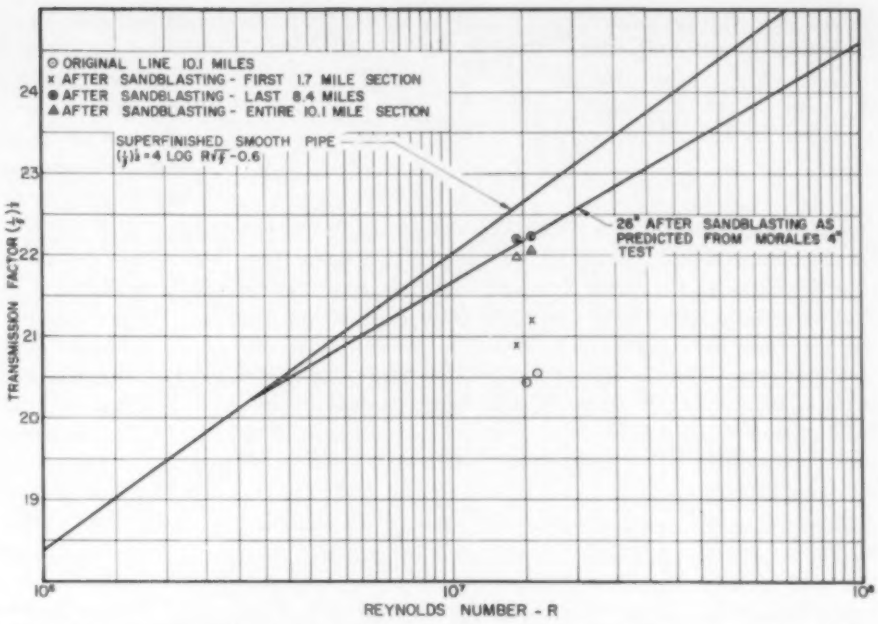

FIGURE 9—Test results: Sandblasting 10.1 miles of 26-inch from one end only. These test points show the difference in the reduction of the surface roughness between the two sections of pipe; 45,000 pounds of sand was used.

SANDBLASTING 30-INCH LINE

Approximately 460 miles of 30-inch pipe had been placed in service last winter. The fourth section chosen to be sandblasted was an 11.2 mile section of this 30-inch with an initial transmission factor of 19.9. This section had the lowest transmission factor of all the 30-inch placed in service. It was also in an extremely hilly terrain which may have been a contributing factor to the low transmission factor. This pipe had been stored for four months prior to installation and considerable rust had accumulated on the interior.

Surface roughness prior to blasting was 180-200 micro-inches. After sandblasting the roughness was reduced to about 80 micro-inches, which is well below the roughness required to produce maximum flow efficiency on the 26-inch. The transmission factor was improved from 19.9 to 22.2, or an improvement of 11.5 percent. Only a single point was obtained on this section and it is shown plotted on Figure 10 which is a composite of the four sections tested.

TRANSMISSION FACTOR CORRELATION

It will be noted that the transmission factors for the first two sandblasted sections exceed the predicted values by about one percent between a Reynolds number of 10 million and 18 million. This can probably be attributed to the effect of stringer beads and icicles. They would have a much greater effect on the flow patterns of a 4-inch diameter line than on a 26-inch diameter line.

Two lines have been drawn through these points on Figure 10. The line marked "A" is drawn parallel to the predicted line and lies about one percent above it. The line marked "B" is drawn parallel to the smooth pipe curve line. Between a Reynolds number of 7 million and 30 million there is less than a one percent difference in transmission factor between these two lines.

If due weight is given to the test points between a Reynolds number of 8 to 11 million, then line "B" is a fair representation of these points. However, these test points were obtained at a pressure level of about 700 psig. Under these conditions, the small pressure drops of 8 to 10 pounds were so low that an error in pressure readings of only a few tenths of a pound could give rise to an error in transmission factor of from one to two percent. On the other hand, the test points below a Reynolds number of eight million were obtained by blowing the gas to atmosphere. Thus pressure drops of from 20 to 50 pounds were measured, and a high degree of accuracy was obtained for these points. If line "B" is a good representation of the test data, then a transition zone must exist between a Reynolds number of about 6-10 million. Test data on the 4-inch pipe line does not indicate that a transition region exists for sandblasted pipe. In view of this, until additional data are obtained the authors believe that line "A" should be used rather than line "B".

The equation for line A is given by:

$$\left(\frac{1}{f_{26}}\right)^{1/2} = 2.90 \text{ Log } 3.345\, R_{26} \qquad (14)$$

which was experimentally determined for 26-inch pipe.

The experimentally determined equation for a 4-inch diameter pipe was given by equation 11 as follows:

$$\left(\frac{1}{f_4}\right)^{1/2} = 2.90 \text{ Log } 1.33\, R_4 \qquad (11)$$

The above curves differ only by a constant. This difference is attributed to a diameter factor. In an effort to correlate these two curves it is assumed that the ratio of these constants bears a relation to the ratio of the diameters raised to some power, thus:

$$\left(\frac{25.375''}{4.02''}\right)^{x} = \frac{3.345}{1.33}$$

Solving for X gives X = 0.500
Equation 11 may now be written

$$\left(\frac{1}{f}\right)^{\frac{1}{2}} = 2.90 \text{ Log } \left[\frac{1.33\ D^{0.500}\ R}{(4.02)^{0.500}}\right]$$

$$= 2.90 \text{ Log } (0.664\ RD^{0.500}) \qquad (15)$$

Equation 15 is an experimentally determined equation for the transmission factor of an internally smooth pipe line of diameter D, for a Reynolds number greater than that corresponding to the point of intersection with the smooth pipe flow curve. An internally smooth pipe line is tentatively defined as one with an arithmetical mean surface roughness of from 80-120 micro-inches or less. Mill coated pipe placed in service in a clean condition, and pipe which is properly sandblasted will usually fall into this category.

It is apparent from equation 15 that if transmission factor is plotted again $RD^{0.500}$ on semi-log paper that it will plot as a straight line, and this single line will give the transmission factor for any diameter pipe and Reynolds number. Figure 11 is such a plot. Also a plot of the friction coefficient is shown.

THE "TRUNKLINE NUMBER" EXPRESSION

The correlation function $RD^{0.500}$ has been designated as the "Trunkline Number," T_N, thus

$$T_N = RD^{0.500} = \frac{D^{1.500}\ US}{Z}$$

where R = Reynolds number
D = inside pipe diameter
U = Velocity
S = Density
Z = Viscosity

This function should prove useful in providing a better understanding of fluid flow in relatively smooth pipe lines.

The pipe diameter marks at the bottom of the curves indicate the lowest Trunkline Number, for which this correlation is valid for that diameter pipe. These marks indicate the Trunkline Number which corresponds to the Reynolds number at which the transmission factor curves intersect with the smooth pipe flow curve. For Trunkline Numbers lower than that indicated for a given pipe diameter, the smooth pipe flow curve applies. A practical transmission pipe line design will always have a sufficiently high Trunkline Number that the correlation on Figure 11 will apply.

Results of the tests on the 26-inch line completely bear out the validity of the extrapolations based on the tests of the 4-inch line and they rather conclusively indicate that the transmission factor of very smooth transmission pipe lines is a function of both Reynolds number and diameter. The Reynolds numbers obtainable in a very smooth practical pipe line are such that there appears to be no transmission factor dependency on surface roughness. This is evidenced by absence of the typical change in slope and flattening of the transmission factor with an increase in Reynolds number.

CONCLUSIONS

The following conclusions can be made based on these tests:

1. It is possible to obtain transmission factors at the usual design flow volumes or Reynolds number that approach within 2 percent of the smooth pipe flow law by sandblasting.
2. Transmission factors of 22.5 can be consistently obtained on 26 and 30-inch pipe at the usual design flow rates.
3. The transmission factor for a sandblasted line and quite probably for a clean mill coated line can be accurately predicted by use of Equation 15.
4. The transmission factor for pipe lines which have been sandblasted is a function of both diameter and Reynolds number. The Trunkline Number ($T_N = RD^{0.500}$) gives an excellent correlation of transmission factors.
5. Sandblasting will reduce surface roughness to a point where it is impractical to get sufficiently high Reynolds numbers to cause the transmission factor to be limited by the absolute roughness of the pipe wall.
6. The effect of pipe wall erosion in field bends is about one mil per 15,000 lbs. of sand in a 26-inch line.
7. The sand gains in polishing and cleaning effect as it proceeds down the pipe line due to its fracturing along the crystal planes.

APPENDIX

The general equation for the flow of natural gas is:

$$Q = 38.7744\ \frac{T_o}{P_o}\left(\frac{1}{f}\right)^{\frac{1}{2}}\left(\frac{P_1^2 - P_2^2}{LTGZ}\right)^{\frac{1}{2}} D^{5/2} \qquad (16)$$

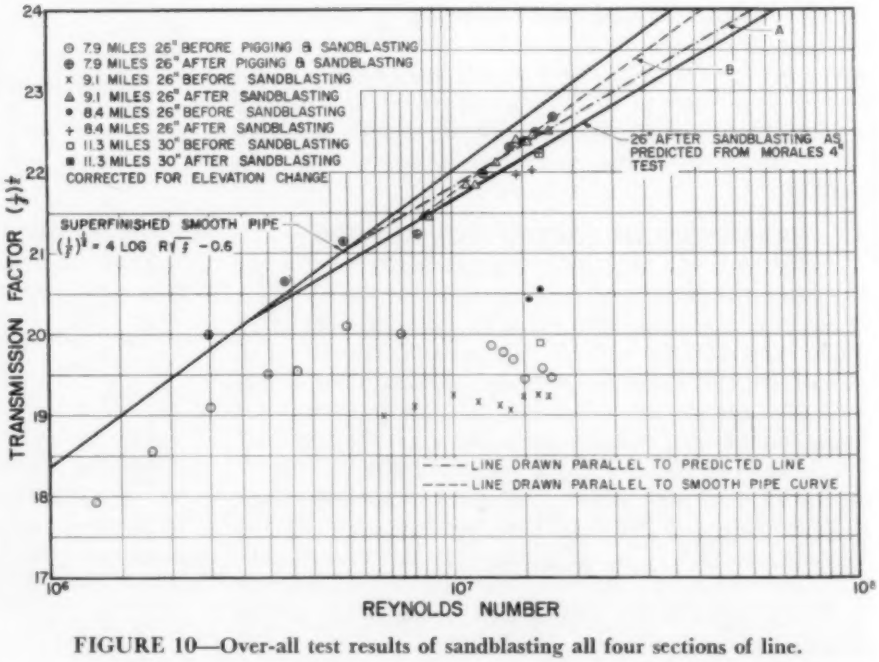

FIGURE 10—Over-all test results of sandblasting all four sections of line.

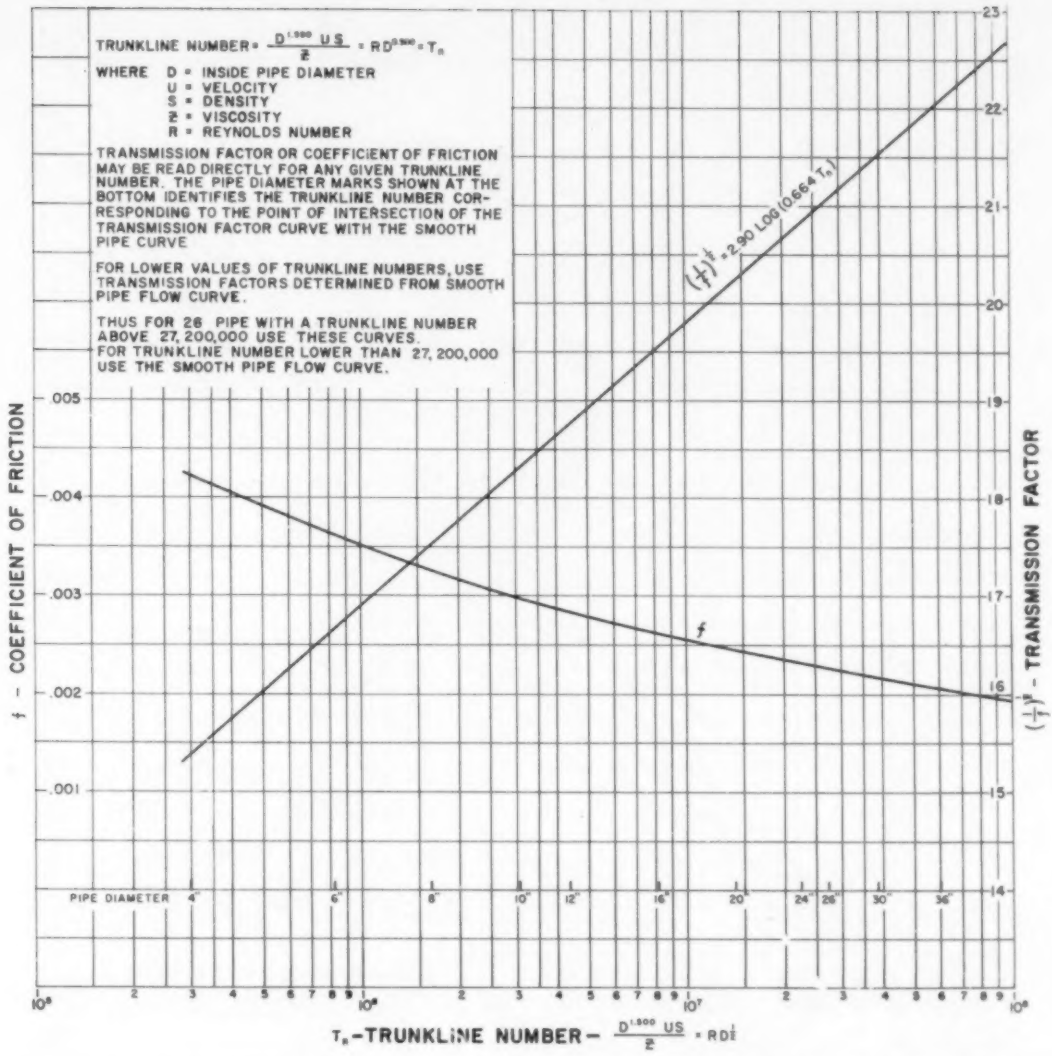
TRUNKLINE NUMBER = $\frac{D^{1.500}\,US}{\mu}$ = $RD^{0.500}$ = T_n
WHERE D = INSIDE PIPE DIAMETER
U = VELOCITY
S = DENSITY
μ = VISCOSITY
R = REYNOLDS NUMBER
TRANSMISSION FACTOR OR COEFFICIENT OF FRICTION MAY BE READ DIRECTLY FOR ANY GIVEN TRUNKLINE NUMBER. THE PIPE DIAMETER MARKS SHOWN AT THE BOTTOM IDENTIFIES THE TRUNKLINE NUMBER CORRESPONDING TO THE POINT OF INTERSECTION OF THE TRANSMISSION FACTOR CURVE WITH THE SMOOTH PIPE CURVE
FOR LOWER VALUES OF TRUNKLINE NUMBERS, USE TRANSMISSION FACTORS DETERMINED FROM SMOOTH PIPE FLOW CURVE.
THUS FOR 26 PIPE WITH A TRUNKLINE NUMBER ABOVE 27,200,000 USE THESE CURVES. FOR TRUNKLINE NUMBER LOWER THAN 27,200,000 USE THE SMOOTH PIPE FLOW CURVE.
$\left(\frac{1}{f}\right)^{\frac{1}{2}} = 2.90 \log (0.664\, T_n)$
f - COEFFICIENT OF FRICTION
$\left(\frac{1}{f}\right)^{\frac{1}{2}}$ - TRANSMISSION FACTOR
.005
.004
.003
.002
.001
23
22
21
20
19
18
17
16
15
14
PIPE DIAMETER 4" 6" 8" 10" 12" 16" 20" 24" 26" 30" 36"
10^6 2 3 4 5 6 7 8 9 10^7 2 3 4 5 6 7 8 9 10^8
T_n - TRUNKLINE NUMBER - $\frac{D^{1.500}\,US}{\mu}$ = $RD^{\frac{1}{2}}$

FIGURE 11—Correlation of transmission factor and coefficient of friction with the Trunkline Number.

where:

Q = Rate of gas flow in cubic feet per day at pressure and temperature bases P_o and T_o

D = Inside diameter of the pipe in inches

L = Length of pipe in miles

T_o = Temperature basis degrees F absolute (519.6°)

P_o = Pressure basis pounds per square inch absolute (14.73 pounds)

f = Coefficient of friction

P_1 = Inlet pressure, pounds per square inch absolute

P_2 = Outlet pressure, pounds per square inch absolute

T = Actual temperature of flowing gas

G = Specific gravity (Air = 1)

Z = Average effective compressibility factor

Flow equations in general use differ only in the treatment of the transmission factor $\left(\frac{1}{f}\right)^{\frac{1}{2}}$. The Panhandle A equation defines this factor as:

$$\left(\frac{1}{f}\right)^{1/2} = \left[52\left(\frac{QG}{D}\right)^{0.1461}\right]^{1/2} \quad (17)$$

Substituting this value for $\left(\frac{1}{f}\right)^{\frac{1}{2}}$ in equation 16 above gives

$$Q = 435.87\left(\frac{T_o}{P_o}\right)^{1.0788}\left(\frac{P_1^2 - P_2^2}{G^{0.8539}TLZ}\right)^{0.5394} D^{2.6182} \quad (18)$$

This is the Panhandle A equation for a pipe line that is 100 percent efficient. Since pipe lines are not 100 percent efficient the above equation is multiplied by an "e factor" which is actual pipe line efficiency.

Thus:

$$Q = 435.87\,e\left(\frac{T_o}{P_o}\right)^{1.0788}\left(\frac{P_1^2 - P_2^2}{G^{0.8539}TLZ}\right)^{0.5394} D^{2.6182} \quad (19)$$

And

$$\left(\frac{1}{f}\right)^{1/2} = e^{0.92695}\left[52\left(\frac{QG}{D}\right)^{0.1461}\right]^{1/2} \quad (20)$$

The compressibility factor is usually combined with the pipe line efficiency factor "e" and equation 19 becomes

$$Q = 435.87E\left(\frac{T_o}{P_o}\right)^{1.0788}\left(\frac{P_1^2 - P_2^2}{G^{0.8539}TL}\right)^{0.5394} D^{2.6182} \quad (21)$$

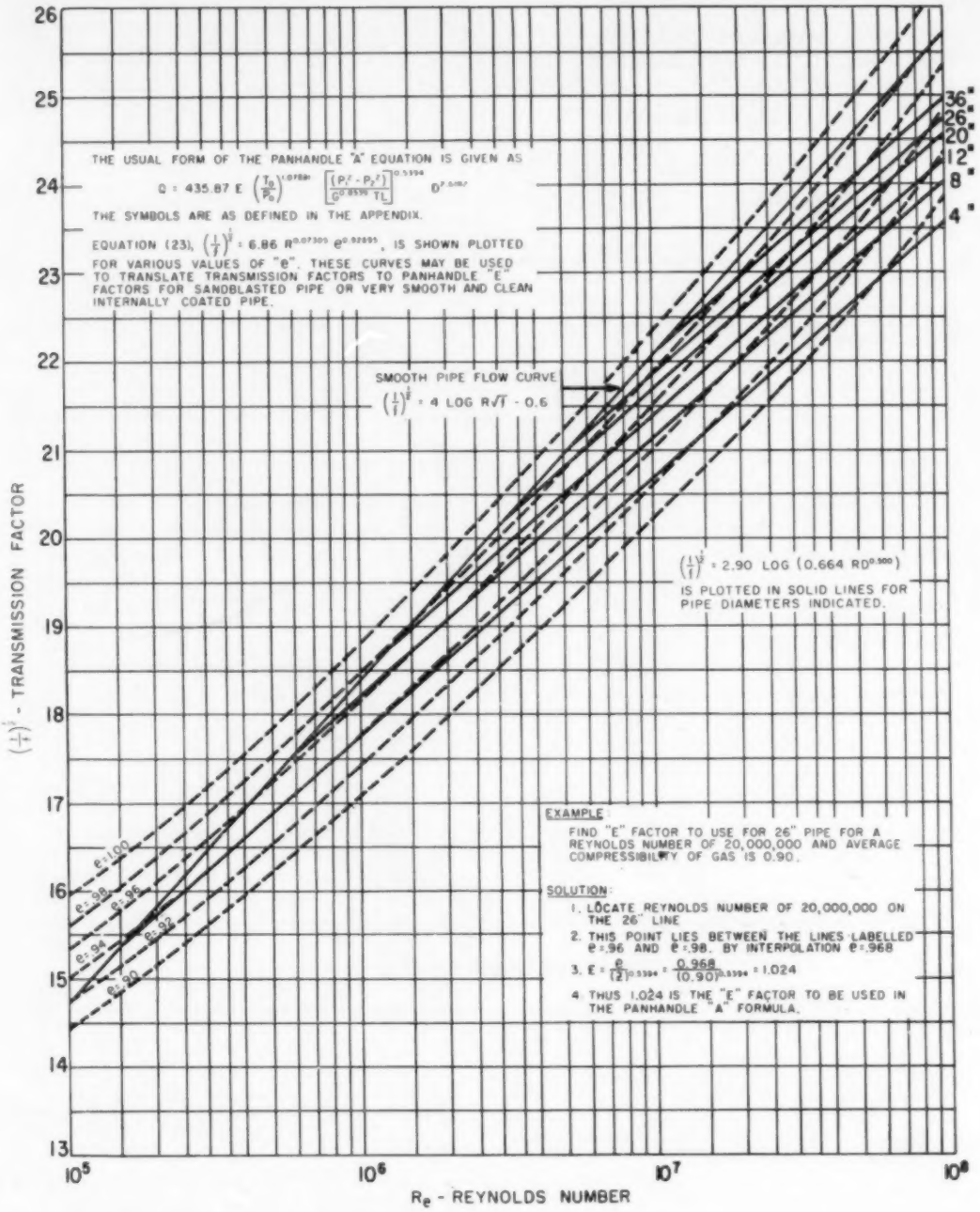
THE USUAL FORM OF THE PANHANDLE "A" EQUATION IS GIVEN AS
THE SYMBOLS ARE AS DEFINED IN THE APPENDIX.
EQUATION (23), $\left(\frac{1}{f}\right)^{\frac{1}{2}} = 6.86\ R^{0.07305}\ e^{0.92695}$, IS SHOWN PLOTTED FOR VARIOUS VALUES OF "e". THESE CURVES MAY BE USED TO TRANSLATE TRANSMISSION FACTORS TO PANHANDLE "E" FACTORS FOR SANDBLASTED PIPE OR VERY SMOOTH AND CLEAN INTERNALLY COATED PIPE.
SMOOTH PIPE FLOW CURVE
$\left(\frac{1}{f}\right)^{\frac{1}{2}} = 4 \log R\sqrt{f} - 0.6$
$\left(\frac{1}{f}\right)^{\frac{1}{2}} = 2.90 \log (0.664\ RD^{0.900})$
IS PLOTTED IN SOLID LINES FOR PIPE DIAMETERS INDICATED.
36"
26"
20"
12"
8"
4"
e=1.00
e=.98
e=.96
e=.94
e=.92
e=.90
EXAMPLE:
FIND "E" FACTOR TO USE FOR 26" PIPE FOR A REYNOLDS NUMBER OF 20,000,000 AND AVERAGE COMPRESSIBILITY OF GAS IS 0.90.
SOLUTION:
1. LOCATE REYNOLDS NUMBER OF 20,000,000 ON THE 26" LINE
2. THIS POINT LIES BETWEEN THE LINES LABELLED e=.96 AND e=.98. BY INTERPOLATION e=.968
3. $E = \frac{e}{(Z)^{0.5394}} = \frac{0.968}{(0.90)^{0.5394}} = 1.024$
4. THUS 1.024 IS THE "E" FACTOR TO BE USED IN THE PANHANDLE "A" FORMULA.
$\left(\frac{1}{f}\right)^{\frac{1}{2}}$ - TRANSMISSION FACTOR
R_e - REYNOLDS NUMBER
26
25
24
23
22
21
20
19
18
17
16
15
14
13
10^5
10^6
10^7
10^8

FIGURE 12—Conversion of transmission factors to "E" factors of the Panhandle "A" equation.

where

$$E = \frac{e}{Z^{0.5394}}$$

Transmission factors for sandblasted pipe may be expressed in terms of Panhandle E factors if the Panhandle transmission factor is expressed in Reynolds number.

For a viscosity of 0.000007 pound per second feet the Reynolds number may be expressed as

$$R = 1.93\ \frac{QG}{D} \qquad (22)$$

substituting

$$\frac{QG}{D} = \frac{R}{1.93}$$

in (20) above gives

$$\left(\frac{1}{f}\right)^{\frac{1}{2}} = 6.86\ R^{0.07305}\ e^{0.92695} \qquad (23)$$

which is the transmission factor for the Panhandle A equation expressed in actual pipe line efficiency and Reynolds number. By use of equations 23 and 15 transmission factors for sandblasted pipe can be converted into "e" factors for use in the Panhandle A equation if desired. Equations 15 and 23 are plotted on Figure 12 and a sample conversion from transmission factor to "E" factor is shown.

ACKNOWLEDGMENT

The tests described in this article were run jointly by Trunkline Gas Company and Sharman, Allen, Gay & Taylor, Inc. The sandblasting equipment used for these tests was designed, supplied and operated by J. D. McCune of Klean Kote Company.

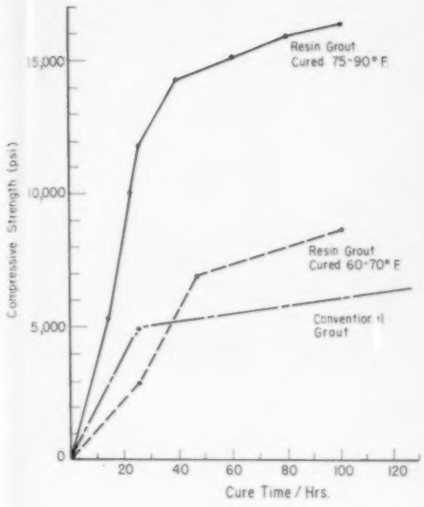

FIGURE 1—Cure-strength rate for resin grout at two different temperatures compared with cement.

FIGURE 2—Placing resin grout under a new pipe line compressor. Grout is worked under the frame using rods, wood or sheet metal strips, chains or vibrators. Material will flow smoothly but it is a good idea to check for possible voids as pouring progresses. Material is workable for 3 to 4 hours, normally.

How to Use the New Plastic Grouts

This new resin-aggregate material can be the answer to a number of compressor grouting problems. Here are points to remember for new station construction or regrouting

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Vice President, Chief Engineer
Rowan & Associates
Houston

USE OF THIS NEW resin-aggregate grout for tough compressor engine service has been growing fast in the last year. First used for regrouting in only the extreme environments of chemical process plants, the grout was found to possess many advantages which proved it is often worth the cost premium in many gas compressor stations. These catalyzed resin bonded materials are completely resistant to oils, have very low moisture absorption, plus high and quick compressive, tensile and bonding strengths. Physical properties are compared with conventional concrete and iron filled cements in Table 1.

TABLE 1—Physical Properties of Grout Materials

	Concrete	Iron Filled Cement	Resin-Aggregate Grout
Tensile (psi)	500	616	2200
Compressive (psi)	5633	7475	16000
Water Absorption	5.7%	4.8%	0.3%
Bond to Steel (psi)	350	400	1400
Flexural Strength	800	....	4400
Secant Modulus of Elasticity (at 300 micro-in.)	....	....	3.1×10^6

Resin grout has much higher physical strength than cement types. Its compressive strength is three times that of concrete and the tensile is over four times higher; its bond to steel can also be used to good advantage in setting compressor engines. This bond to clean steel is 1,400 psi and the bond to concrete is inseparable.

Another important property of resin grout is the speed of its setting; it achieves a high strength in a much shorter time than cement grouts. Figure 1 shows the cure rate of resin grout at two different ambient temperature ranges along with the cure-

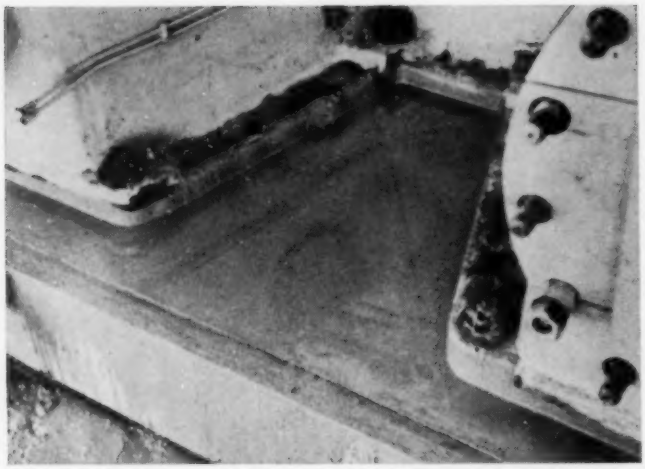


FIGURE 3—Completed grout job before removal of forms and cleanup. Because of the strong bonding properties of the resin, the forms and side of the engine near the base should be thoroughly coated with a paste wax.

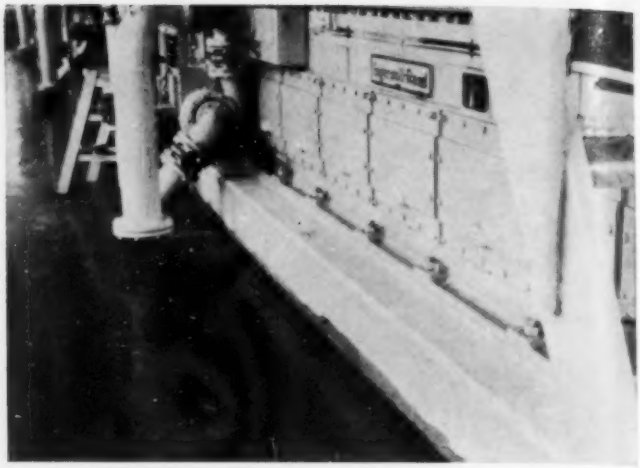


FIGURE 4—After waxed forms are removed and compressor has been cleaned. This was a new 1,320 horsepower unit installed at Texas Gas Transmission's Youngsville, La., station. Grout material has high compressive, tensile and bond strengths.

rate of a conventional grout.

Strength of the resin-grout after 24 hours of curing compares favorably with the seven-day strength of cement grout. This means that shims can be removed from an engine only 16 hours after grout is poured and the engine may be placed in service within only 48 hours.

Chemical properties of the resin material enable it to provide permanent alignment of the engine base. It is not weakened by prolonged exposure to oil nor mechanical stresses which could allow distortions of the base and crankshaft. Such distortions over long engine service will cause excessive bearing wear and eventual crankshaft failure.

Grouting A New Engine. Use of the resin grouts is only slightly different from conventional methods, but there are a few points which must be observed. The accompanying photos show how these materials were used to grout a new 1,320-horsepower engine compressor unit at Texas Gas Transmission Corporation's Youngsville, La., station. In preparing to use the resin grouts check these preparation steps:

- Be sure that the top of the concrete base has been roughened to remove laitance and that all surfaces are completely dry.
- If the anchor-bolt sleeve is to be filled with grout all water must be removed; if the anchor-bolt sleeve is to be left ungrouted, seal off the bolt hole with felt or rags.
- Areas that are not to be grouted, such as the oil pan, must be sealed off. Several successful methods for sealing off pans have been used; Perhaps the most common is to use a fire hose wrapped with polyethylene or vinyl tape or sheet, then waxed throughly with a paste wax. The hose is then filled with water, air-bled off and it is pressured to 5-10 psi; Oakum or soft rope material may be placed under the pan edges before the engine is lowered. When using either method it is a good idea

FIGURE 5—Regrout: Step 1. Beginning of a regrout job. Original cement-iron filled grout had failed after 3 years' service; note broken anchor bolt.

FIGURE 6—Regrout: Step 2. With the weight of the engine on the jack-screws, old grout was chipped out from beneath the base.

to pack wet sand under the oil pan so if leakage should occur it will be stopped by the wet sand.

- Coating of forms is very important. Before erecting them, cover them with an extra heavy coat of paste wax. It is often necessary to put on at least two coats as the first sinks into the wood; Forms may be shellacked first and then waxed well to save waxing time. Cover all wedges, shims and levelling screws to prevent the grout from adhering; model clay, glazing putty or similar materials that stick and don't harden will be satisfactory for this.

- Before the engine is lowered in place, the bottom surface must be throughly cleaned with solvent.

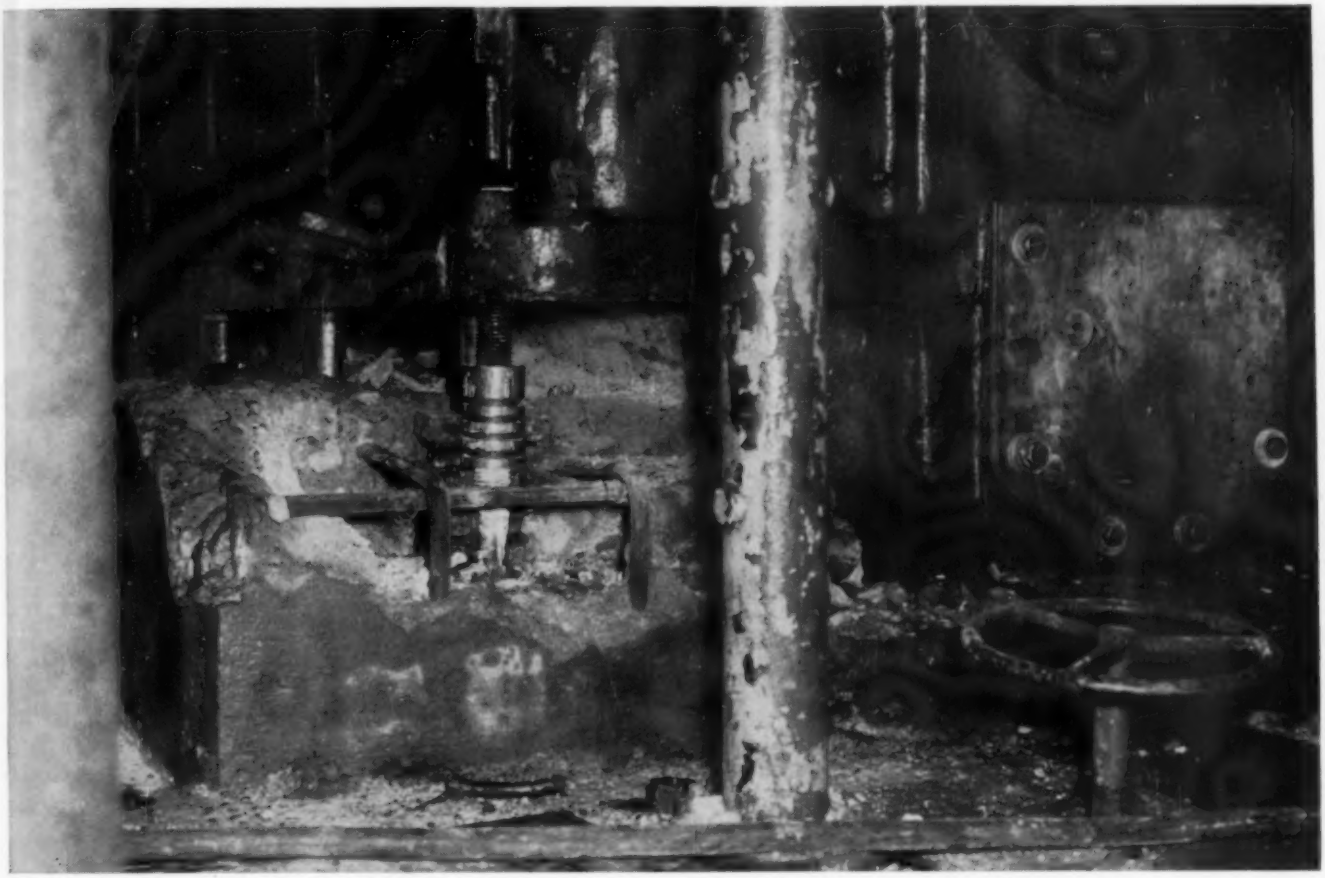


FIGURE 7—Regrout: Step 3. End view of engine base shows that grout was not removed adjacent to pan. Concrete is chipped away below reinforcing steel and number one anchor bolt repaired.

FIGURE 8—Regrout: Step 4. Placing grout after forms have been placed. Procedure is very similar to that described for original grouting of new engine once base has been thoroughly cleaned with solvent.

FIGURE 9—Regrout: Step 5. End view after removal of forms show how grout is poured higher than bottom of base plate. Bond strength helps to stabilize base to minimize vibration or horizontal movement.

It is well to wipe traces of soil or light rust after equipment is lowered in place, too. Paint should be removed from edge of base with a disc sander or wire brush; it is necessary to mask along this line ½ to 1-inch up alongside the engine base with either masking tape or paste wax. To speed cleanup after grouting, a number of crews have waxed the engine surfaces from the top of the masked line to about 12 inches above the oil trough to protect against accidental splashing of the resin during working.

Placement Of Grout

- For flat bottom engines it is better to work grout from one side through to the other. On flat bed type machines, which are only being grouted part way underneath or where the oil pan will not be grouted, it is a good idea to start at one end of the form and fill one side completely with grout, advancing to the other end. Grout is worked under the frame using rods, plywood or sheet metal strips, barrel staves, rods, chains, vibrators etc.
- The resin grout flows easily but it is well to check frequently for leaks because they do not self-seal and could cause voids under the engine.
- Forms should be left in place until the grout is hard enough throughout so that it cannot flow. It is usually convenient to leave them on overnight; but it may be necessary to leave them on longer in cold weather. Grout will usually be workable under the engine for a minimum of two to three hours.

Notes On Cold Weather Curing. Resin grouts may be placed without damage in cold weather, however they will not cure in freezing temperaures; they will cure properly later when ambient temperature rises. Curing may be speeded by circulating either warm cooling water, or warm oil from another engine through the one being grouted. The foundation and the engine will ordinarily be colder than room temperature unless station temperature has been constant for a long time.

When grouting engines in cold weather, the materials should be stored in a warm place. Cold grout is stiff and hard to handle. For best working, ingredients should be around 70° F or higher. Curing time requirements for various temperatures are shown in Table 2.

TABLE 2

Ambient Temperature	Remove Shims	Place Engine In Service
90°	16 hours	48 hours
80	24	72
70	36	96
60	72	144
50	96	168

Re-Grouting Engines. Resin-aggregate grout is finding application for re-grouting a number of engines in gas pipe line service where its physical properties and inertness justify its use. In many instances the high strength grout eliminates the need to lift engines for complete re-grouting. Accompanying photos show how re-grouting was carried out on an engine compressor that had been in service for several years. The old iron-filled cement grout had been deteriorated from oil and stress. Vertical movement of the frame had caused a failure of the Number 1 anchor bolt. Crankshaft distortion was evidenced by measured deflections as high as 0.010 inch, which were well above the manufacturer's tolerances.

To make a repair to an engine without lifting it from the foundation, it is necessary first to put the weight on the jack screws; the old grout is then chipped out along the side as shown in the photos. No attempt was made here to remove the grout immediately adjacent to the oil pan; original grout was left approximately out 2-inches from the oil pan. Once the grout was chipped away around the periphery of the engine base, the engine was realigned and the base cleaned thoroughly with solvent. Forms were then placed and the engine was regrouted with the resin aggregate in much the same way as described earlier.

Where old grout is left alongside the oil pan, the sideward thrust of the engine is sustained by bringing the new grout up along the side of the engine base to about one-half inch or so. Shear strength of the resin materials permit this technique in re-grouting. A fillet of flexible grout is then applied to the top of the grout along the side of the base to prevent oil penetration at this juncture. This procedure has been carried out on over 100 re-grout jobs in the field with good success.

Cost and the Future. Use of the new resin-aggregate grout has also proved satisfactory for skid-mounted compressor units where a minimum of material has to do a secure holding job. While more expensive than conventional grouting materials, the strength, chemical inertness, anticipated long life, reduction of labor for re-grouting and quicker start-up of the engine have often been more than offsetting. Six years of field experience have proved these materials and the methods for using them.

ACKNOWLEDGMENT

The author wishes to thank W. A. Severance, Technical Director, the Ceilcote Company, Inc., Cleveland, Ohio, and G. A. Suddoth, Supervisor, Compressor Station Construction, Texas Gas Transmission Corporation, Owensboro, Ky., for portions of the technical material presented in this article.

About the Author

Robert L. Rowan, Jr., was graduated in mechanical engineering from the University of Virginia in 1948. He spent five years in the drilling industry and for the past seven years has been with Rowan & Associates, Houston. Rowan is a registered professional engineer in Texas, a member of ASME, Texas Society of Professional Engineers and the Society of Petroleum Engineers of AIMME.

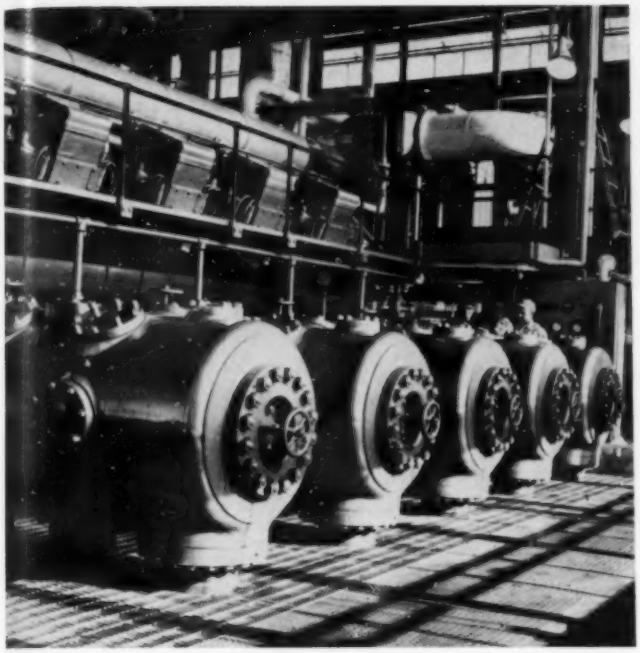


FIGURE 1—Eliminating the overhead suction bottle eliminates much of the vibration trouble experienced at compressor stations. Shown here is Trunkline's new 3,000 horsepower compressor unit at Longville, La. There is hardly any perceptible vibration in cylinders and piping.

Trunkline Solves Vibration Problem

By changing positions of inlet and outlet nozzles on compressor cylinders, Trunkline engineers virtually eliminate vibration in piping

Lester C. Sullivan, Research & Development Supervising Engineer, Trunkline Gas Company, Houston

NEW COMPRESSOR cylinder designs have eliminated all major vibration in suction and discharge piping adjacent to the compressor cylinders on a new engine-compressor unit installed at one of Trunkline Gas Company's stations.

Trunkline engineers had worked out the design changes in theory; and when the company placed a new 3,000 horsepower unit in service at its Longville, La., compressor station last year, they saw their designs prove out. The new compressor cylinder's record of performance has proved highly gratifying to its designers.

Cylinders on the Trunkline engine depart from conventional design by

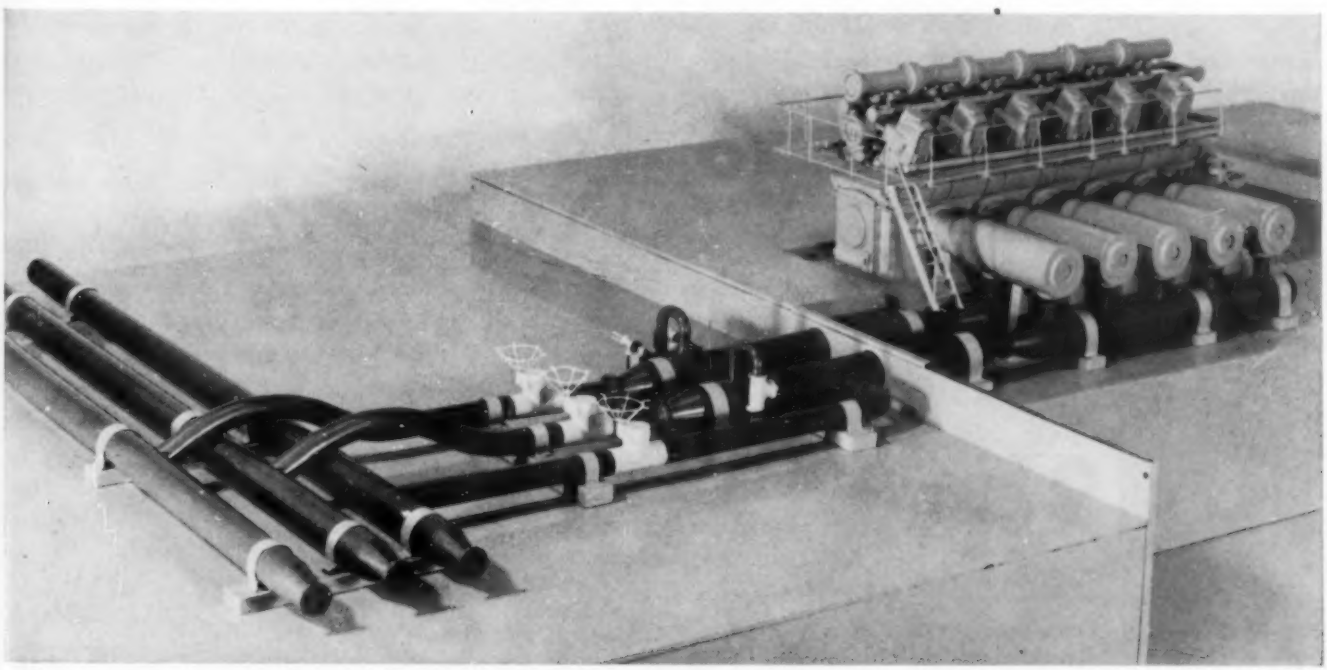


FIGURE 2—Model of gas piping. Bottles are underneath compressor cylinders. Extra in-line bottles minimize piping vibration.

the positioning of their inlet and outlet nozzles. Instead of the suction nozzles being on top of the cylinders, they are located on the bottom side along with the discharge nozzles—out of sight, and relatively free of vibration.

The cylinders, which were built in accordance with Trunkline specifications by the manufacturer, are mounted on a new KVT-512 engine. Extensive tests have been carried out on the piping and cylinders over the entire operating range—from a compression ratio of 1.15 to 1.80, and speeds from 250 to 330 rpm.

No movements greater than .003 of an inch have been detected on either the piping or the cylinders!

To better visualize the important benefits derived from this type of cylinder design, we should examine the origin and manifestation of compressor cylinder and piping vibration:

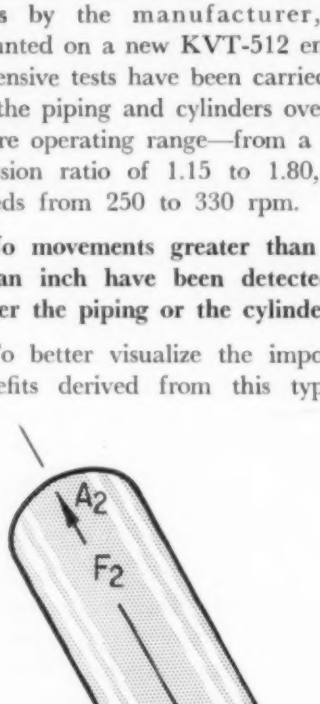


FIGURE 3—Forces resulting from standing waves in compressor cylinder can be explained as follows: Areas at opposite ends are equal, pressures are equal and forces F_1 and F_2 are equal when cylinder is subjected to static pressure. But standing wave causes pressures to vary and equilibrium will not exist; vibratory movement will result unless the container is externally restrained.

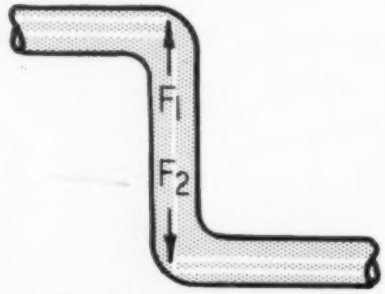


FIGURE 4—Forces from standing waves at elbows will cause vibratory movement unless the piping is externally restrained or elbows are eliminated.

Origin of Vibration. The compressor cylinder is, of course, the fluctuating energy source. It periodically accelerates a mass of gas at multiple acceleration rates. The product of these masses and accelerations produce forces which must find equal and opposite forces to decelerate them. The compressor piping, unfortunately, must supply these forces. Because gas is compressible, the problem is further complicated by standing waves set up in the gas between any two reflection points formed by the piping.

Explanation. The consequent forces resulting from these standing waves may be explained as follows: A container (such as shown in Figure 3) subjected to a static internal pressure will not move because there is no unbalanced force. Since areas A_{x1} and A_{x2} are equal and the pressure P_{x1} and P_{x2} are equal, the forces F_{x1} and F_{x2} must be equal because they are a product of their respective areas and pressures. In the case of a standing wave P_{x1} instantaneously may be greater than P_{x2} while in the next instance P_{x2} will be greater than P_{x1}: Consequently, equilibrium does not exist and vibratory movement will result unless the container is externally restrained.

This same phenomenon occurs at elbows. From Figure 4 and the previous reasoning, we see that if P_{x1} is not equal to P_{x2} equilibrium will not exist and here, too, movement will occur unless adequate external restraint is supplied.

One solution to the vibration problem is to replace the reciprocating compressor with a centrifugal compressor which is inherently almost free from vibration. However, the reciprocating cylinder has a higher efficiency than the centrifugal, which often dictates its use regardless of the vibration problems that it imposes. Therefore, to utilize this efficient piece of equipment, a great deal of research and development has been necessary to design piping which is less responsive to the pulsation generated by compressor cylinders. Unfortunately these designs are not always compatible with cylinder performance.

Aims. Not only must the piping be mechanically stable, but also it must have a reasonably low pressure drop and not interfere with the cylinder performance. On the previous conventional cylinder these requirements were often conflicting. In order for a cylinder to perform properly, it must have a large column close to both the suction and discharge of the cylinder. This generally means a long length of large diameter pipe must be placed on top of the cylinder so that it is close to the suction nozzles. This pipe, generally referred to as a "bottle," is subjected to considerable unbalanced force; yet, there is little or no way to restrain it except with the compressor cylinders themselves. Unfortunately, these compressor cylinders provide little or no restraint at certain frequencies.

A typical cylinder mechanical response curve is shown in Figure 5, where the amplification factor is plotted against frequency of the applied force. As shown by the curve at the cylinder resonant frequency the amplification factor can approach or even be greater than 1. This means that there is no restraint to the bottle at that particular frequency. So, if the gas applies a force at or near this frequency, not only the piping but the cylinder as well will respond and move as though there were no restraint.

Effects of Resonant Frequencies. Curiously enough this is exactly what happens on a great many installations. The mechanical resonant frequency of the present day compressor cylinder usually falls somewhere between 15 and 35 cycles per second depending on its weight, its construction and the way it is attached to the engine and foundation. Cylinders operating at normal speeds of from 180 to 330 rpm (3 to 5.5 rps) generally produce pressure fluctuations which are quite large in this 15 to 35 cycle range. Also, to further aggravate the situation, the suction bottle's length is

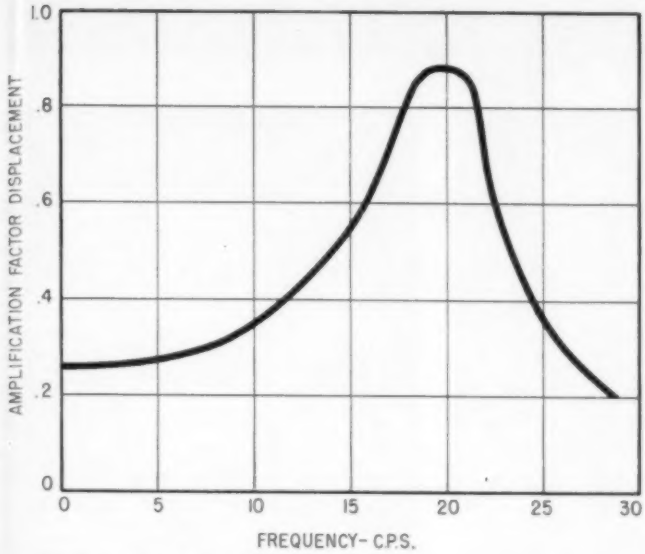


FIGURE 5—Typical cylinder mechanical response curve where amplification factor is plotted against frequency of the applied force. Note that at the cylinder resonant frequency, the amplification factor can approach or even exceed one.

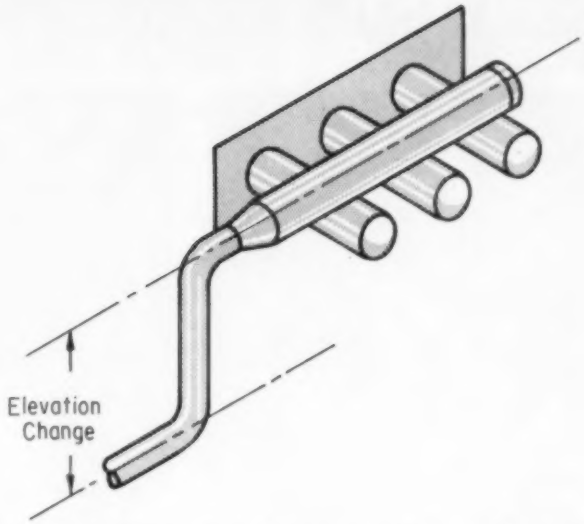


FIGURE 6—Elbows eliminated by new cylinder design also eliminate source of unbalanced forces which are difficult to restrain. With new cylinder, no elevation changes are necessary and no elbows are needed.

often acoustically resonant in this frequency range. This causes the maximum variation between P_{x1} and P_{x2}. This, in turn, produced the maximum unbalanced forces. The center line distance between two adjacent cylinders is such that this is most likely to occur on engines equipped with three or more compressor cylinders. Unfortunately, this is the number of cylinders required to efficiently absorb the power of a 2,000 to 3,000 horsepower engine.

Using Internals to Solve Problem. A great deal of excellent work has been done in recent years to minimize the unbalanced forces in bottles. This often necessitates a rather complicated configuration of piping to be inserted within the offending bottle. Even though these internals have done much to reduce vibration, they have created problems of their own. In some cases where these internals are not supported properly they break loose and, nearly always, they will have a detrimental effect on the cylinder performance. This, of course, tends to defeat the original purpose in using this type compressor. Because the designer is faced with several problems whose solutions are conflicting, he is at best able to produce only an acceptable compromise design.

The New Cylinder Design. With this new type cylinder, both the suction and discharge bottle are located underneath the cylinder where adequate anchors and supports may be provided to restrain the bottles independently of the compressor cylinder. With greater restraint, larger forces can be permitted in the bottles. Consequently, the internal piping with its detrimental effects can be reduced or in some cases eliminated.

The position of the suction bottle mounted on the previous conventional cylinder requires a combination of at least two elbows and/or tees to make the necessary elevation change. For illustration, this piping has been sketched in on Figure 6. This configuration of elbows and tees is also a source of unbalanced forces which are very difficult to restrain. **With the new cylinder no elevation changes are necessary, therefore this difficulty is completely eliminated.**

In addition to the design benefits just discussed there are features which are desirable from a maintenance and operational viewpoint. Listed below are some of these advantages:

1. The space above the cylinders is clear for easy crane access.

2. The water formed by sweating of the suction piping during humid weather does not drip on the cylinders, floor, or floor grates.

3. Noise level is reduced on the operating floor. Any movement of the piping produces noise in the basement or pit and will be muffled before reaching the operating floor.

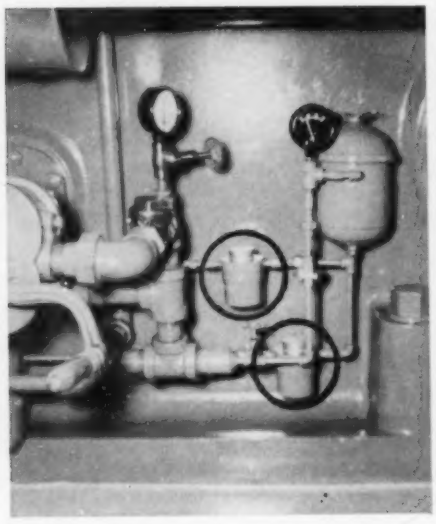
4. The suction bottle does not interfere with cylinder maintenance.

—The End

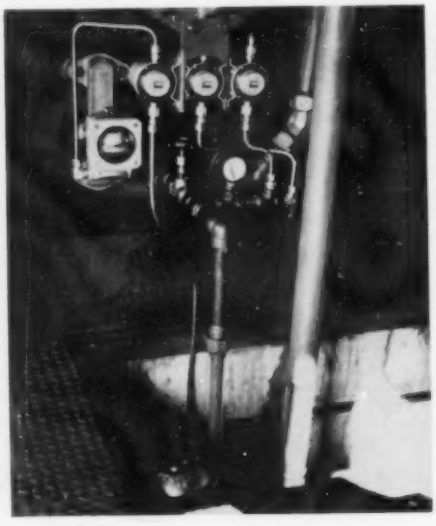
Sullivan

About the Author

Lester C. Sullivan, supervising engineer for research and development at Trunkline Gas Company has been employed by the Houston-based gas pipe line firm for 5½ years. A native of Springfield, Mo., he received his B.S. degree in mechanical engineering from Texas A&M College. Before joining Trunkline Gas, Sullivan worked two years as technical service engineer for El Paso Natural Gas Company. Earlier, he worked two years for Texas Electric Service Company of Fort Worth. He served in the U.S. Air Force as a flight engineer during both World War II and the Korean War.



400 midget meters, like the ones inside the circles, have been installed on the Natural Gas Pipeline Company of America system. Above meters were installed on a 1,250 horsepower horizontal engine at the company's Stinnett, Texas, station.

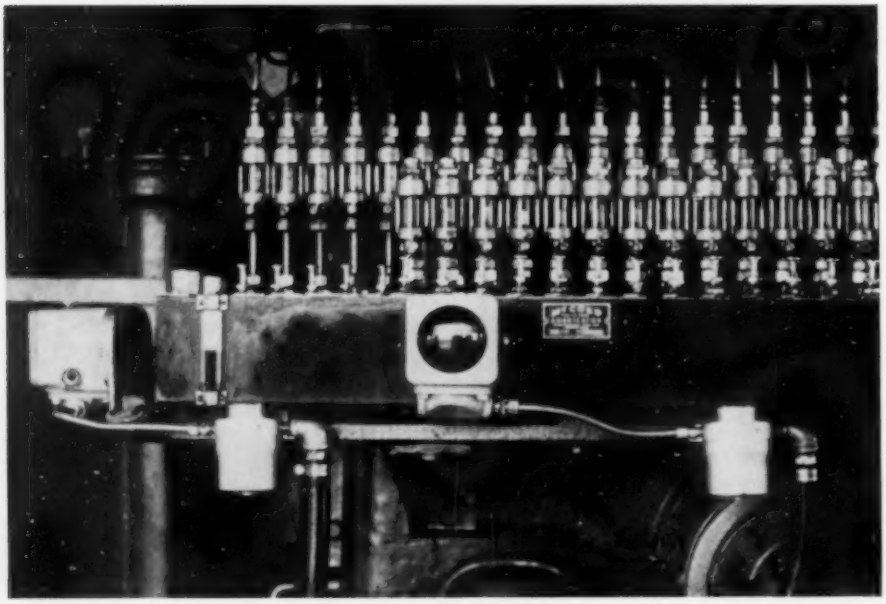


Oil is metered as it is force-fed through pump from underground storage facilities. Meters will operate and record in any position.

Close-up of one of the small positive displacement meters, which make constant measurement of oil consumption possible. Meters register to 9,999.9 gallons and then start over. One of advantages of the meters is that possible trouble can be spotted in time to prevent lengthy downtime.

Midget Meters Keep Tab On *EACH* Drop of Oil

These tiny positive displacement meters which can measure oil by the drop or by the gallon are a must for automation



Three meters, two of which are shown here, measure oil consumption of the power cylinder, compressor cylinder and crankcase.

Natural Gas Pipeline Company of America has installed over 400 small positive displacement meters which can measure lube oil by the drop or by the gallon, and keep tabs on it indefinitely. Engineers are able to make important and revealing studies of the lubricating systems of reciprocating engines since installing the meters and their findings point to new efficiencies in lubrication.

One thing that is apparent about the meters: they may well be a must for compressor station automation.

Natural Gas Pipeline engineers reported that by automating the lubricating system, they have eliminated the hand measuring and filling of oil reservoirs on engines. With the meter, operators and supervisors are able to be sure how much lubricating oil each

engine is using and the individual identity of each engine is maintained. Too, operators can be sure that each engine is receiving enough oil to do the lubricating job. In addition, the local superintendent and the home office Compressor Department find that the oil meter readings help with cost analysis and in determining the all-important *cost per horsepower hour.*

It is the policy of Natural Gas Pipeline to have operators read the meters once per day. The time of taking the reading is of no importance, because the registers continue to record indefinitely, providing a continuous tally of oil consumption.

The meters have no minimum flow requirement—they will measure as little as a fraction of a gallon per hour. The maximum flow rates vary with the viscosity and temperature of the oil being measured. (Natural Gas Pipeline uses SAE 30 at temperatures in the 70° F range to the crankcase and 120° F to the lubricators.)

What's measured? Each compressor is completely equipped with meters at all three areas of lubricating oil use—crankcase, power cylinder and compressor cylinder. While the meters will function on a gravity feed, Natural Gas Pipeline uses a 20 psig air blanket on the lube oil storage tank. This is sufficient to feed all crankcases at the station. The engine oil pump, of course, feeds the lubricators.

Savings. The accurate measure of oil consumption for each compressor is the prime purpose of the new meters, and this has produced savings and benefits, including low operation and maintenance cost and the prevention of serious damage to the expensive compressors through insufficient or excessive make up flow.

By automating this maintenance function and providing a positive check on make-up oil, the possibility of human errors in record keeping has virtually been eliminated. The meters register 9,999.9 gallons and then repeat.

The meters read equally well in any position, vertical or horizontal.

ACKNOWLEDGMENT

Photos from The Service Recorder Co. 1013 Rockwell Avenue, Cleveland 14, Ohio.

API Technology School Completes Tenth Term

More than 250 pipeliners from throughout the world have graduated from the extensive six-weeks course held semi-annually at Lee College in Baytown, Texas

By Donald G. DePugh
Construction Editor, PIPE LINE INDUSTRY

WILLIAM WINFIELD BROOKS, a maintenance and construction coordinator, has been with Humble Pipe Line Company for over 30 years. It hardly seems likely that he'd be going to school today. But fact is more amazing than fiction and Brooks has just completed a six-weeks course at the tenth semi-annual School of Pipe Line Technology.

The school is a joint venture of the API Committee on Personnel Training, Division of Transportation, and the Petroleum Extension Service of the University of Texas, conducted at Lee College in Baytown, Texas. The recent term was held from April 10 to May 19.

Brooks and 24 other pipeliners with varied experience underwent six weeks of lectures, field trips and demonstrations to cover the practical, as well as theoretical, aspects of all segments of liquid pipe lines from public relations to dispatching.

Wilbur Holleman, Jr., Ernie Rettig, Grove; and N. G. Payne, inspect valve.

As in previous terms, nearly 50 percent of the students were from foreign pipe line companies and many of them had little pipe line experience.

Enrollment is held to around 30 students which allows plenty of classroom discussion and attention to individual technical problems.

Instructors. The school has the advantage of long experienced pipeliners from major pipe line companies who serve as instructors. These instructors are specialists in their fields who cover every phase of the industry including such topics as economics, right of way, hydraulics, land construction, offshore construction, inspection, testing, corrosion, valves, coatings, gathering systems, tank farms, stations, automation, measurement, communications, welding, etc.

This affords the pipeliners the latest information on developments and techniques in the rapidly advancing industry. More important, these "working instructors" bring out practical solutions to actual problems brought up in class.

Field Trips. Coupled with classroom pipelining are field trips to actual pipe line installations including terminals, pumps stations, valve manufacturers, steel mills and electronic control manufacturers.

Seeing line pipe rolled at the mill and valves built in the plant brings out many questions and answers that otherwise would not be thought of.

Students making tour of WKM plant at Missouri City, Texas, include Giampaolo Bonfiglioli, SNAM, S.p.A.; John Redpath, Marathon Pipe Line Co.; Giovanni Osvaldo, SNAM; Clarence Whitlock, Jr., Atlantic Pipe Line Co., Eleuterio Salazar, Anaco Mobil Oil Co. of Venezuela; Dov Arnon, Eilat Pipeline Co. Ltd.; N. G. Payne, Continental Pipe Line Co.; Alberie Khachaturian, National Iranian Oil Co.; George Parry, Shell-Mex & BP Ltd.; Henry Qualls and William Brooks, Humble Pipe Line; Mario Lonardi, SNAM; John McCullough, Britamoil Pipe Line Co., Ltd.; Lt. Col. Carroll Danforth, Quartermaster School, Fort Lee, Va.; Herbert Maduro, Shell of Venezuela; Walter Nickolls, Sinclair Pipe Line Co.; Oscar Morgan, Southern Pacific Pipe Lines, Inc.; Wilbur Holleman, Jr., Williams Brothers Co.; Harold Reed, Detroit Southern Pipe Line Co.; Giacomo Laghi SNAM; Robert Faith, Cities Service Pipe Line Co.; Bill Hanna, Mid-Continent Pipe Line Co.; Don Jennings, Mid-Continent; Joseph Williams, Williams Brothers; Wolf Stratmann, Deutsche Shell, A.G., and Adrianus Akveld, N. V. Rotterdam-Ryn Pypleiding.

Demonstration at W-K-M shows how valve is disassembled for maintenance in the field.

John Collins (left), president of Grove Valve and Regulator Company, chats with William Brooks while pipeliners investigate valves at Grove plant in Oakland, Calif.

These trips during this session included inspection of Cameron Iron Works, W-K-M, Division of ACF, Grove Valve and Regulator Company, Humble Pipe Line Company's Baytown terminal, A. O. Smith Corporation and International Controls Corporation.

Students. Aside from language problems the foreign students sometimes encounter, the pipeliners contend that the school is a great help. Most of the students are well informed in either construction, engineering, operations or financing, but lack fundamentals in other departments. Some have had much practical experience and little theory while the opposite may be true for others. The school of technology is designed to give fundamentals as well as advanced education in all areas of the industry. Between lectures, field trips and continuous exchange of ideas among students, they accumulate a greater understanding of each facet of pipelining which better equips them in their own work and improves their value to the company.

Some companies have sent two or more employes to the school in split shifts with each student receiving two or three weeks of study. Literature, handbooks and papers that are distributed at school provide further information for the participants and can be used for reference material later.

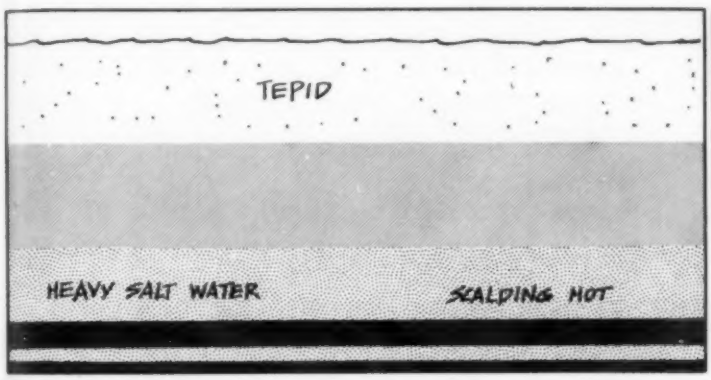
The school is especially beneficial to international students who have the opportunity to make personal acquaintances with many pipe line, engineering and manufacturing firms in the U.S.

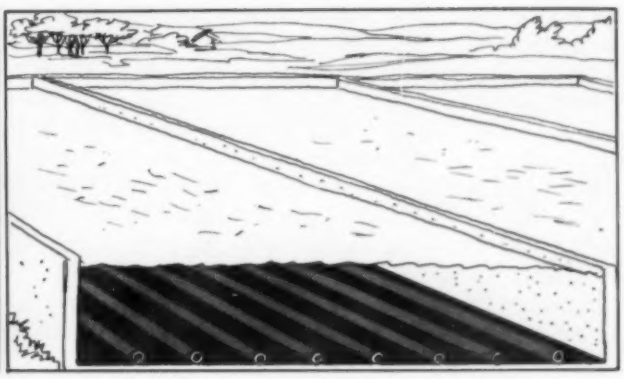
Administration. Russell Brannon, Humble Pipe Line Company, chairman of the API Committee on Personnel Training, is coordinator-in-chief of the school. Other coordinators include Morgan Martin, Gulf Refining Company; T. E. Anderson, The Texas Pipe Line Company; R. G. Kastendieck, Shell Pipe Line Corporation; H. E. Freeman, Sun Pipe Line Company; J. L. Walker, Continental Pipe Line Company, and R. L. Bullock, Interstate Oil Pipe Line Company.

The operating coordinator is James E. Conway of The University of Texas. The School's next term will be held this fall. —The End

Ideas for the Future

By **Donald M. Taylor,** Engineering Editor





Solar ponds may provide practical means of harnessing the sun's rays

Experiments near the Dead Sea show how large areas of heavy brine water may enable mankind to harness the energy of the sun, directly.

The idea originally came from Hungary where scientists discovered bottom waters in a certain lake were warmer than top waters. The explanation was a difference in density. Adapting this, Israeli scientists have used heavy brine for the bottom waters of a "solar pond" and not-so-salty water on top.

The result is an inversion of what happens normally where heated bottom water rises to the top. In this case, the heavy brine is denser than the water above it and it stays at the bottom. The lighter water on top serves as a transparent lid or insulation barrier.

By painting the bottom of the pond black, rays of the sun get the bottom waters hotter and hotter and the heat cannot evaporate because the non-mixing layers of water prevent convection.

In the Dead Sea experiments it was found that whereas water at the top is merely tepid, the salt water two or three feet down would easily scald the skin off one's hand.

In shallow ponds, the heat could be transferred to generate electricity. Also, the heat could be used to desalt sea water on a large scale.

Organic semiconductors open new vistas in electronics industry

In March, PIPE LINE INDUSTRY (Page 58) described organic solids with low electrical resistance that may soon be used as electrical conductors. The possibilities offered by such materials are highly exciting to electronics engineers, but they are not causing a fraction of the stir that came in April when DuPont engineers described work with *organic semiconductors.*

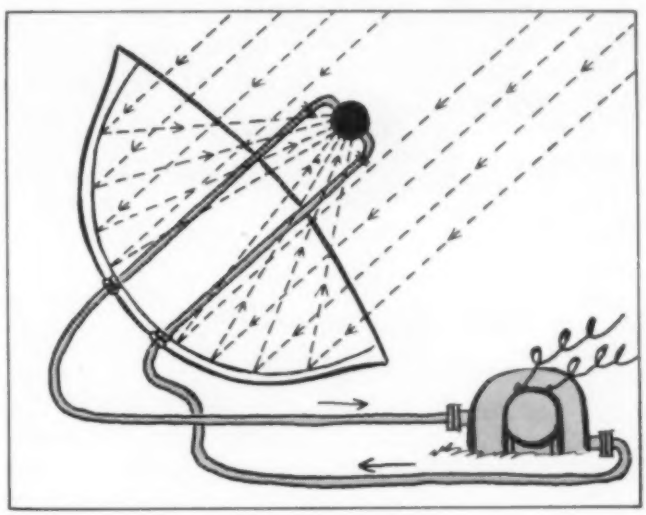
The two main advantages scientists envisage for the new organic semiconductors over inorganic are:

1. The organic semiconductors will be cheaper than present inorganic semiconductors made of such materials as selenium, germanium, silicon and copper oxide.

2. The organic semiconductors could be tailored for a specific job. Right now, electronic engineers must accept compromises in semiconductors, simply because inorganic compounds do not provide great flexibility.

Other possibile advantages of organic semiconductors pointed out by DuPont are: possibly greater resistance to heat, easier forming, greater resistance to shock and unlimited sizes.

If this keeps up, one day Joe Blotts, Jr., age 10, in the fourth grade, may pipe, "Ancient man made crude television sets using crude materials such as copper, tungsten and glass . . . He sure was crude!"



Solar Cookers point up some of the difficulties of "Doing Good"

We are a friendly people.

It distresses us that our fellow man living in "have-not" lands is not able to enjoy the blessings we have found on this bountiful planet. And *alas,* we persist in trying to do something about this state of affairs.

Take the solar cooker for example. Several groups of our scientists had set out to investigate ideas which might

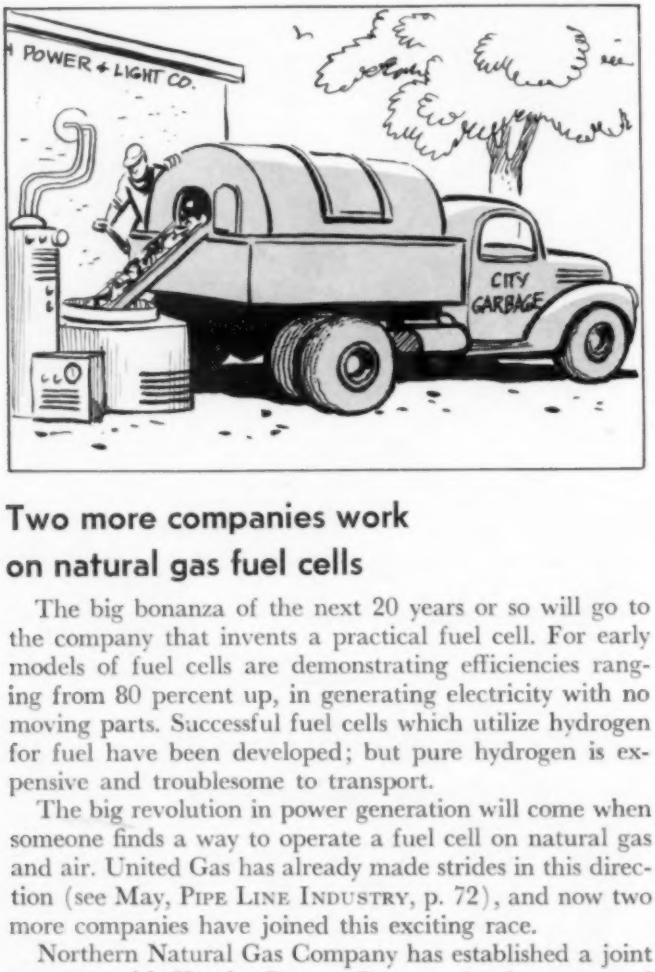
improve the lot of impoverished peoples in our own hemisphere and in south Asia. One such group happened on the idea of developing a solar cooker which could utilize sunlight for cooking in place of such fuels as cow dung and sticks.

After some years of research and development, came success! A highly efficient solar cooker made inexpensively of plastic performed faultlessly from a technical standpoint; and with warm hearts and high hopes, the scientists set out to introduce their innovation to those they pined to help.

But despite the fact that they merely wanted to give them away for free—or for no more than a few of the paltry dollars the hot stove idea got the cold shoulder. In India, the women simply did not like them. They didn't want to cook in the open, they liked cow-dung fuel. And that was that.

In one village in Mexico, the solar cookers were fairly successful; but in another village, the natives would eat no food prepared in such a device.

Still, we are a stubborn lot, and once we set out to do *good* it takes bullets to dissuade us. Even now we are designing and testing solar furnaces which can be coupled with storage batteries to supply electric power for villages in these backward areas. We want the natives to own TV's, washing machines, etc. and we'll see that they get them despite hell, high water or Russia.



Two more companies work on natural gas fuel cells

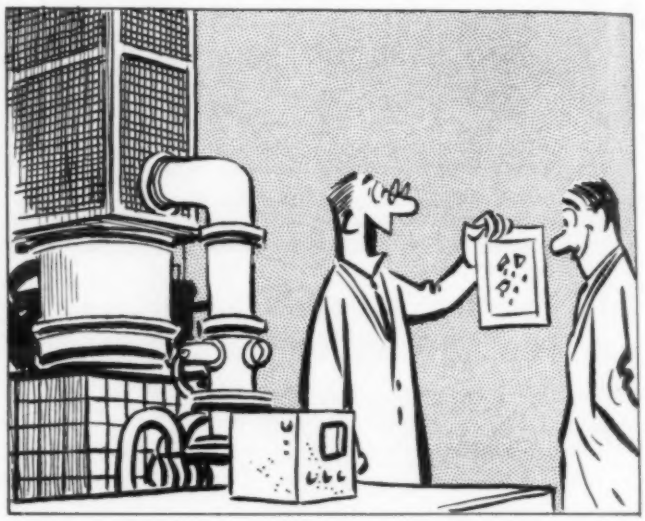
The big bonanza of the next 20 years or so will go to the company that invents a practical fuel cell. For early models of fuel cells are demonstrating efficiencies ranging from 80 percent up, in generating electricity with no moving parts. Successful fuel cells which utilize hydrogen for fuel have been developed; but pure hydrogen is expensive and troublesome to transport.

The big revolution in power generation will come when someone finds a way to operate a fuel cell on natural gas and air. United Gas has already made strides in this direction (see May, PIPE LINE INDUSTRY, p. 72), and now two more companies have joined this exciting race.

Northern Natural Gas Company has established a joint program with Houdry Process Corp. to develop a natural gas fuel cell. Houdry is well known in the petrochemical field, and the company's specialty has been development of catalysts.

And the very core of this problem lies in the field of catalysts. Presumbably, the correct catalyst will join natural gas and oxygen in such a way that electricity will be produced. Yet the catalysts should have the ability to resist "souring" or else be easily regenerated.

The high efficiency of the fuel coupled with our vast and efficient gas distribution systems could cause quite an upheaval in electric power generation and distribution.



Powerful electron microscope takes 'beautiful' photos of living germs

From France comes the announcement that three scientists have developed the world's most powerful electron microscope. And with it, for the first time, the very smallest living creatures can be observed on the instrument's fluorescent screen and photographed. French scientists have described photographs of living bacilli which measure only 12-millionths of an inch, as being "astonishingly beautiful."

The four-ton, 10-feet-high instrument was developed at Toulouse Electronic Optical Laboratory, a main branch of the National Center for Scientific Research. The microscope has four lenses—one of which weighs a ton—and it can operate at voltages up to 1.5 million.

The innovation that makes it possible to photograph living organism is an airtight box with windows made of material which resists the vacuum of the instrument, even though the thickness of the windows is only 1/10th of a micron. This airtight box which has a volume of about 1/10th cc replaces the conventional slide, and makes it possible to photograph all of the life stages of a bacterium enlarged 50,000 times.

The fastest switch in electronics

Raytheon engineers have devised a switch that operates in less than one-billionth of a second. To accomplish this, they incorporated their avalanche mode silicon transistor in a microwave strip transmission line. This is the first time that a semiconductor has been combined in a switch circuit with a microwave strip transmission line. The device will be used in pulse generators and in other instrumentation circuitry.

How to do it

PIPE LINE HINTS

$10 is paid for each illustrated acceptable contribution. Mail to The Editor, PIPE LINE INDUSTRY, P. O. Box 2608, Houston 1, Texas

Photo: Courtesy International Harvester Company.

Clean Crankcase Vent Prolongs Engine Life

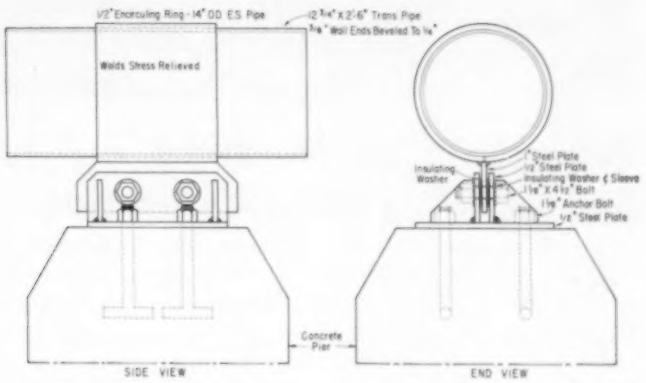
Crankcase vents are the most misunderstood and neglected part of an engine, according to the Service Department of a leading engine manufacturer. When the vents aren't kept clean, they cause trouble and shorten an engine's life.

Here's the explanation. When an engine fires, a highly corrosive, acid gas forms, along with one gallon of water per gallon of fuel burned. Most of these combustion products go out the exhaust, but some escape past the rings into the crankcase. Only fresh air can remove them.

Most heavy-duty engines rely on positive type crankcase ventilation. The intake manifold draws off the fumes and vapors as fresh air is admitted through a hose from the air cleaner. If screens on the breathers stop up, trouble will come.

For example, on a turbocharged engine, the turbo seals suddenly started leaking after 1,500 hours. When they were replaced, the new ones lasted only a few hours. After a third seal fared the same, a service man was called. He found the breathers plugged tightly. How did this cause the trouble? Turbocharger oil seals are the compression type. A pressure balance is required between the air and oil and between the exhaust gases and oil pressures. If the balances are disrupted, the seals will leak. The plugged breather caused excessive pressure in the crankcase, and the pressure escaped through the turbocharger return line. The back pressure caused the seals to leak.

The solution is to remove the breathers every 250 hours, inspect them, and soak them in solvent. This takes about 10 minutes, and it pays off over and over again.



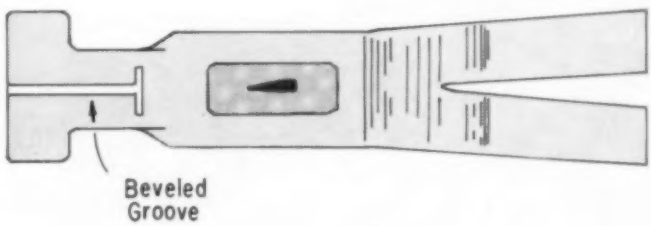
How to Make Insulating Above-Ground Pipe Anchor

Anchoring a pipe line at a pig receiving and launching location presents problems. When the installation is not insulated, it can cause trouble with the cathodic protection system.

Shown here is the solution to this problem. The anchor assembly which makes use of insulating washers can be shop fabricated.

The saddle which goes around the pipe should be welded to a pup joint, stress relieved—at least with a heating torch and carefully examined for undercuts. The supporting linkage, should be machined in the shop and welded to the underside of the saddle.

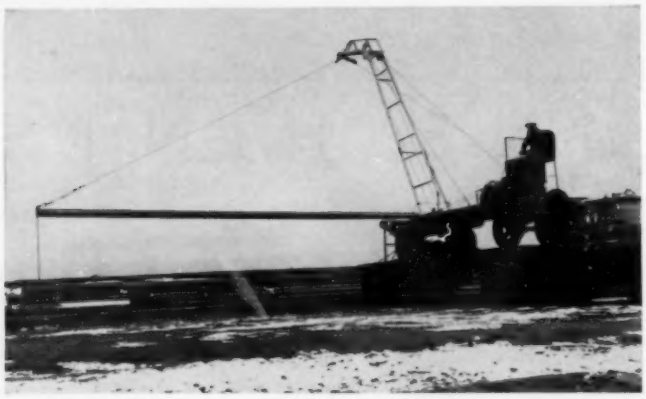
Insulating washers and spacers should be used as shown.



Groove Hammer Head To Make a Nail Starter

Groove the head of a hammer as shown, so 6- and 8-penny nails will fit into it and you will have an excellent nail starter. This should be a finger-saver and at the same time it should speed work. The groove should have a slight bevel so the nail can be wedged into it.

The same thing can be done with a tack hammer.



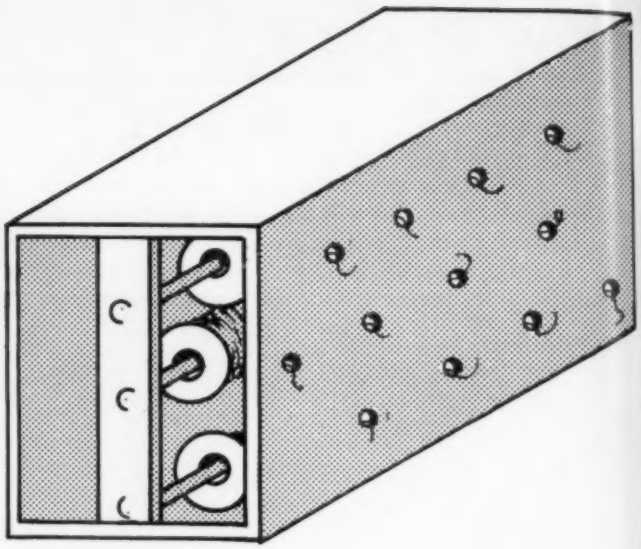
Pipe Handling Machine Speeds Unloading Operation

The time spent unloading or loading pipe is totally unproductive so far as a pipe line company is concerned, and W. E. (Bill) Scott, Panhandle Eastern's manager of stores in the Liberal, Kan., area decided to do something about speeding up this operation. He drew a plan for an improved pipe handling machine, enlisted the aid of E. L. Duff, K. W. Markley and O. T. Morgan.

Using two wornout pipe trailers, some used pipe, floor plate, a four-cylinder engine and two discarded winches, the men constructed the pipe handler for about $1,000, and because of its improved speed and safety, the machine paid for itself almost at once.

Some of the advantages of the "ginny," as it is affectionately known, are: 1. Its two winches permit independent or simultaneous movement of the boom and the load lines. 2. The operator is protected by a guard which doesn't interfere with his vision of the work. 3. The machine is much faster than other methods used. In one day, the machine unloaded three cars of pipe, moved 50 miles and unloaded two more cars. 4. It can operate from the ground or from a float as shown here.

Details of construction are apparent from the picture. The boom is made of pipe—triangular in cross section. Two lengths of wire rope which go to either end of the pipe, are guided through fair leads on the bed of the machine. The boom is live, but non-revolving.



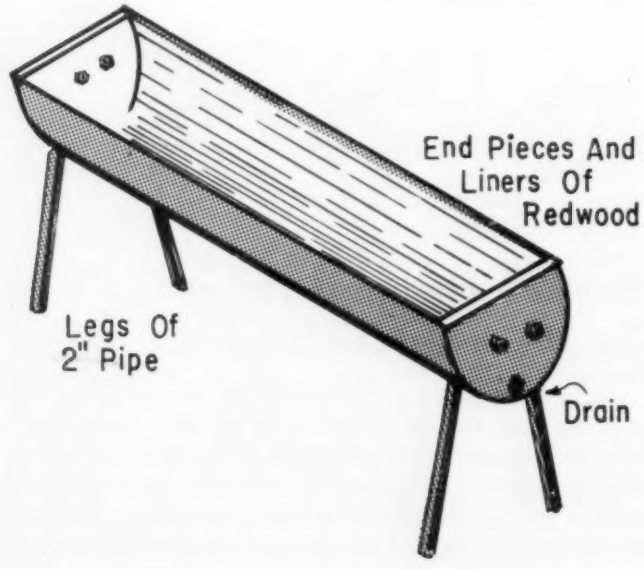
Wooden Cabinet for Wire Aids Electrician at Work

You can store spools of wire on spindles inside an electrician's cabinet, and unreel the wire as it is needed. This protects the reels, saves wire and helps with the housekeeping.

A common sight around the station electrician's shop has often been a hodge-podge of reels of wire lying about. This causes waste and disorder.

The cabinet shown here which can solve the problem is easily made. Note that the reels of wire fit loosely on the spindles with enough play for the individual reels to work back and forth as they unreel.

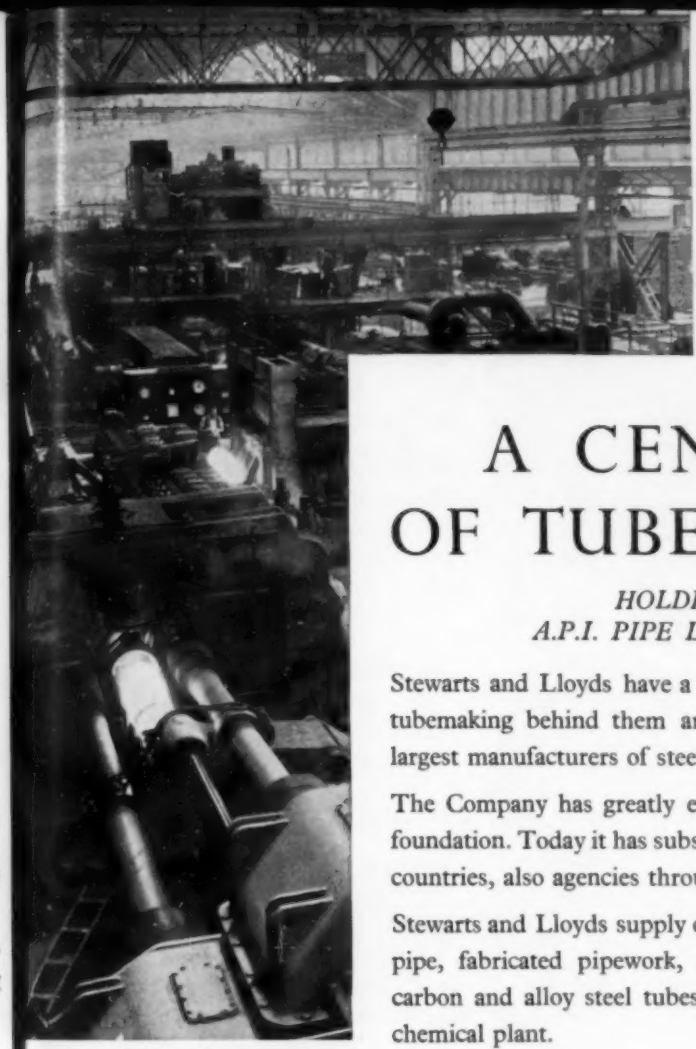
For convenience, the ends of the cabinet are left open and the top of the cabinet can be removed so the three spindles can be lifted out of the box. As they are replenished and placed back in the cabinet, wire from each reel is fed into one of the holes in the face of the cabinet. The holes should be labeled, giving size and color of wire.

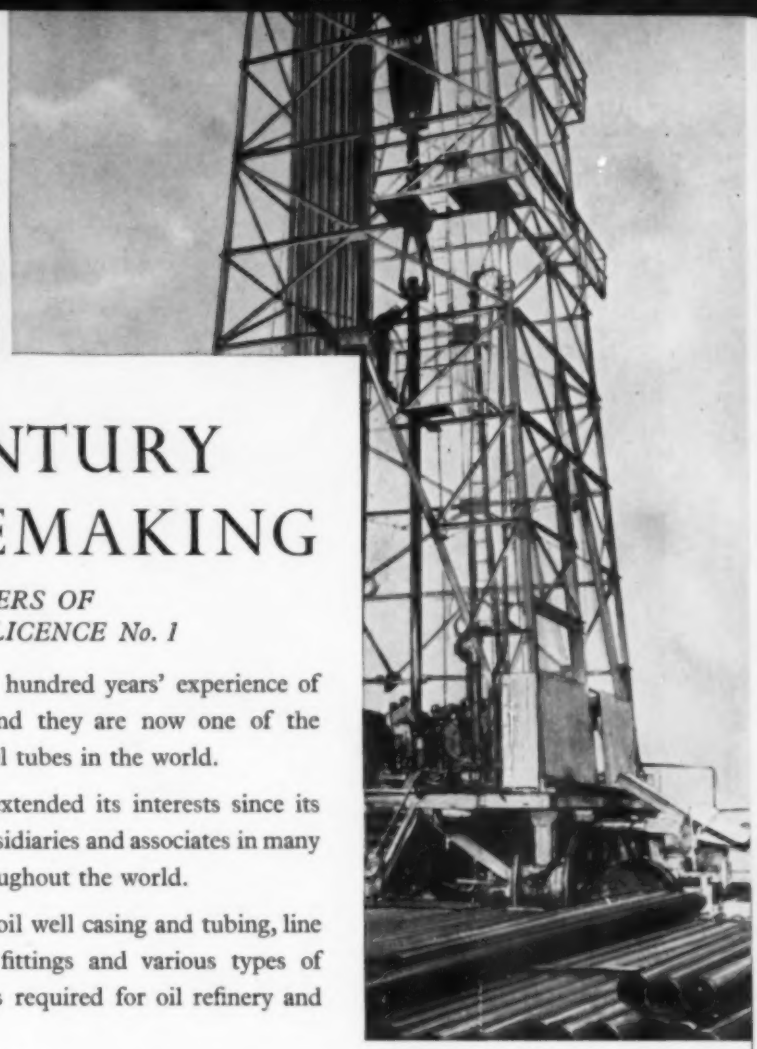


Line Cleaning Vat with Wood And Protect Machine Parts

Come annual overhaul and the speed of doing repair jobs is highly important. This means that the usual parts cleaning operation must be carried out with more than usual speed and this brings up a hazard so far as highly machined engine parts are concerned. Where a solvent trough made of a half section of pipe is used, the part ordinarily will come in contact with steel. The solution is to line the trough with red wood or cedar.

The edges of the boards should be mitred to prevent cracks and they should be laid in place and clamped in place with the heavy 2-inch-thick end pieces which are bolted to the steel ends.





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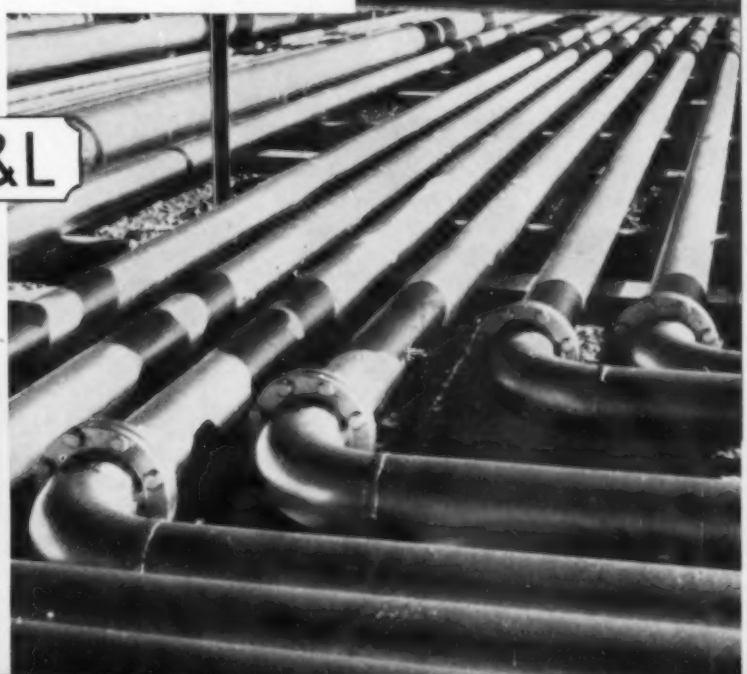
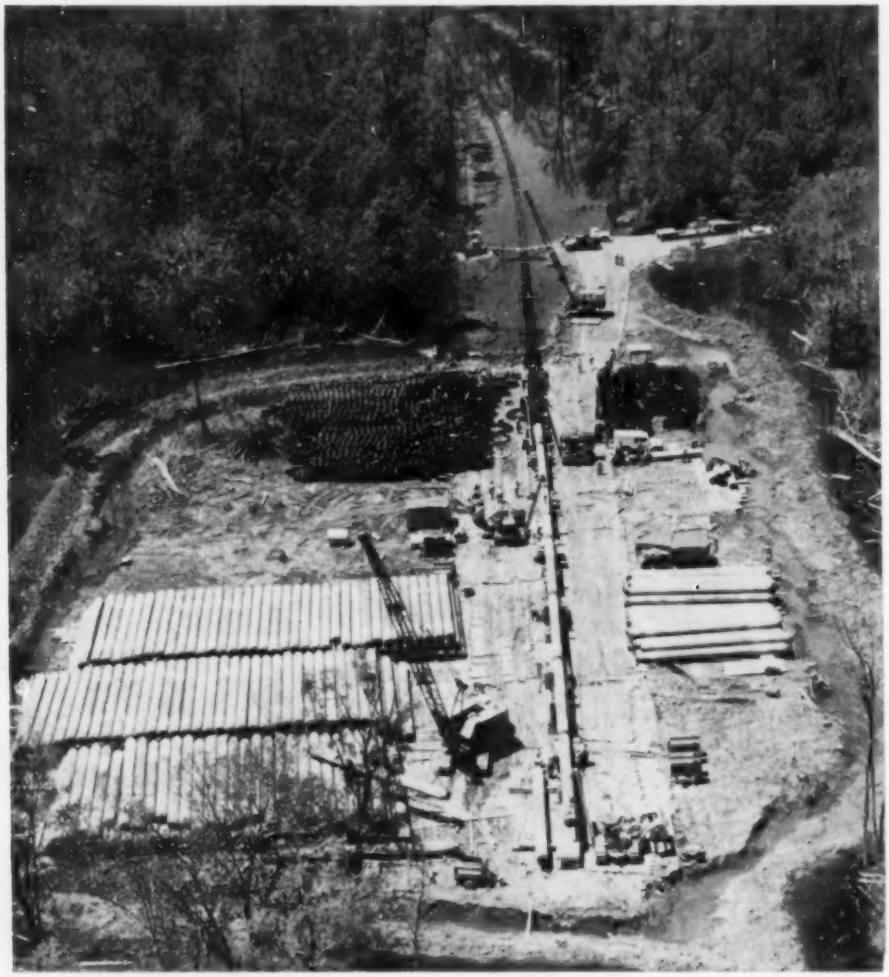


WHAT'S HAPPENING IN PIPE LINE CONSTRUCTION

By Donald G. DePugh, Construction Editor



Gas Line Through Louisiana Swamps

A 4-mile section of American Louisiana Pipe Line Company's 24-mile gas linking Krotz Springs, La., with the main line near Baton Rouge, was laid in the swampy Atchafalaya Floodway. Glaser Construction Co. had to use backhoes for trenching and launched the pipe from a welding station. Spud barges pulled the pipe as tractors pushed it into the water filled trench. The line takes gas from Gulf Oil Corporation's Krotz Spring plant.

United Gas Pipe Line Company Receives FPC Temporary Approval on Major Projects

The Federal Power Commission has granted temporary authorization to United Gas Pipe Line Company for construction of its 217-mile, 30-inch gas line from Lafayette to Monroe, La.

The $32 million line will have a capacity of 358 MMcf of gas per day.

United Gas Pipe Line Company has received temporary authorization for construction of a 59-mile, 36-inch gas line. The $17 million project would extend from Bastian Bay to Lirette, La. It will transport 330 MMcf of gas daily.

The FPC conditioned the authority upon acceptance of temporary authorizations granted to two independent producers proposing to sell to United. The producers, Gulf Oil Corporation and Tidewater Oil Company, had proposed initial prices of 24.8 cents per Mcf including tax reimbursement. FPC conditioned authorization to 23.25 cents (inclusive of tax reimbursements) and requiring the refund to United of any amounts later found by FPC to be excessive.

FPC Approves $54 Million Transco Expansion Program

Transcontinental Gas Pipe Line Corporation has been authorized by the FPC to build facilities costing $54 million.

The projects include 286 miles of 30-26-inch loops in Texas, Louisiana, Mississippi, Alabama, Georgia and South Carolina. An additional 38,540 horsepower in compressor stations; 7 miles of 16-inch sales laterals, and 1.2 miles dual 12-inch river crossing and 6 miles of small diameter purchase laterals.

Transco also received temporary approval on 37 miles of small diameter lines to take natural gas produced in Ship Shoal and South Pelto Areas, offshore Louisiana.

Mountain Fuel Plans 103-Mile Gas Pipe Line

Mountain Fuel Supply Company and Utah Natural Gas Company has filed with the Utah Public Service Commission for permission to construct a new gas line in Utah.

Mountain Fuel would lay a 103-mile, 20-inch line from the Uintah Basin to a juncture with Utah Natural's present 18-inch line at Clear Creek, Carbon County, with costs and ownership to be shared by both companies. Also Mountain would purchase half interest of Utah Natural's 18-inch line from Clear Creek to Orem, Utah, and 100 percent interest in the facilities necessary to operate the line.

The application also calls for Mountain Fuel leasing Utah Natural's remaining 50 percent interest in Clear Creek-Orem line and its undivided interest in the proposed Uintah Basin-Clear Creek line. Mountain Fuel also would purchase gas from Utah Natural at Clear Creek, Joe's Valley and Flat Canyon fields at the well instead of sale at Orem.

Texas Eastman Co. Plans Products Line

A 280-mile, 6-inch products line is planned by Texas Eastman Company of Longview, Texas.

The line will extend from Longview to Houston and will carry propane for Eastman's Longview plant.

Welding 36" FIXED pipe automatically!

. . . this is a major welding break-through that greatly reduces welding costs on cross country pipelines. 500 ampere Hobart *Micro-wire* units with specialized feeder controls and specially controlled analysis wire produce X-ray quality welding in all positions and eliminate weld cleaning. These fully automatic units are now in service at Burney, California on a 36", 500 mile gas line. The equipment was designed by the H. C. Price Company in conjunction with Crose-Perrault and Hobart Brothers Company. For more complete information, write Hobart Brothers Company, Box PL-61, Troy, Ohio.

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"Manufacturers of the world's most complete line of arc welding equipment"

Double Jointing-Coating Yard

The Alberta-California 36-inch gas line now under construction is being double jointed and yard coated at 20 yards along the route of the $300-million project. Above, H. C. Price coats double jointed pipe at Hauser, Idaho, yard. Asphalt, fiberglass and felt paper are applied.

Oasis Oil Company Lets Contracts On Libyan 30-inch Crude Pipe Line

Oasis Oil Company has awarded contract for construction of its 130-mile crude system in Libya. Libyan Engineering and Construction Co. and Arabian Bechtel Corporation will lay the line which is scheduled to open next summer.

The line consists of 86 miles of 30-inch from Dahra to Es Sider on the Gulf of Sirte with a 36-mile, 20-inch lateral from Mabruk to the main line.

Ohio Oil Company, Continental Oil Company and Amerada Oil Corp. own Oasis. Three companies, Esso Sirte, Libyan American Oil Co. and W. R. Grace & Co., own the Mabruk field and will have interest in the pipe line. The system will be named the Sidrah pipe line.

A terminal with seven 3 million barrel capacity storage tanks will be erected at Es Sider. Communications facilities and gathering lines also will be constructed.

Fish Forms Pipe Line Co. To Build 550-Mile System

The Oklahoma Illinois Gas Pipeline Co. has been formed to build a 550-mile gas line from Oklahoma to St. Louis and Western Illinois.

Pan American Petroleum Corp., which holds large leases in Northwest Oklahoma, and Fish Engineering Corporation are developing the project.

The line would originate near Woodward, Okla., extend through Northern Oklahoma, Southeast Kansas and across Missouri to St. Louis. It also will cross the Mississippi River into Illinois.

Oklahoma Illinois Gas Pipeline Co. will file with the FPC seeking permission for construction of the line when further plans are completed.

Trunkline Gas Company Receives FPC Approval

Trunkline Gas Company has received FPC authorization on its $18 million expansion project designed to increase its capacity approximately 55 MMcf of gas per day.

Construction program will include 74 miles of 26-inch gathering line from Longville to Cow Island, La., and 24 miles of 18-inch gathering line from Cow Island to the Gulf shore. Trunkline also will add 3,000 horsepower at each of eight stations between Longville, La., and Johnsonville, Ill.

Trunkline still has pending before the Federal Power Commission, an application seeking permission to conconstruct 97 miles of 30-inch loops between Longville and Tuscola, 27 miles of supply laterals and two 6,000 horsepower stations.

Transco Seeks Permission To Develop Storage Field

Transcontinental Gas Pipe Line Corporation has filed an application with the Federal Power Commission seeking permission to develop the Wharton gas storage field in Potter and Cameron counties, Pennsylvania, at a cost of $38 million.

Transco plans to develop the field in a joint venture with United Natural Gas Company of Oil City, Pa. Total capacity of field will be 24 billion cubic feet of storage annually. Of that 18 billion will be available for Transco.

The field will be developed over a period of three years and give Transco a total storage capacity of 740 MMcf per day. Transco plans a new gas line to connect Wharton with Leidy storage field in Clinton and Potter counties, from which Transco had a 200-mile line to the New York-New Jersey area. This line will be partially looped and horsepower added.

Contracts Awarded On Westcoast Crude Line

Contracts have been let on the 505-mile, 12-inch crude line from Taylor to Kamloops, British Columbia. Dutton-Williams Brothers Limited, will construct 361 miles and Canadian Betchel Limited, will lay the remaining 145 miles.

The line will be owned and operated by Western Pacific Products & Crude Oil Pipe Lines Ltd. Westcoast Transmission Company Limited, is the parent company.

The line ties into Trans Mountain Pipe Line system at Kamloops, near Savona. Capacity of the system will be 75,000 bpd.

Canadian Betchel will lay the northern section of the line and Dutton-Williams has the southern section to Kamloops.

Contracts Awarded On West Shore Pipe Line

Contracts have been awarded on West Shore Pipe Line Company's 285-mile, 10-16-inch products pipe line from Chicago to Green Bay, Wis.

Midwestern Contractors, Inc., Contracting and Material Co., Panama-Williams Corp., Houston Contracting Company, and Somerville Construction Co. will lay the line.

Anadarko Production Co. Plans 83-Mile Gas Line

Anadarko Production Company, subsidiary of Panhandle Eastern Pipe Line Company, plans to lay an 83-mile, 10-12-inch gas line from the Spivey-Grabs-Basil field to Skelly El Dorado, Kan., refinery.

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Guarantee Positive Seal – Extra Long Service Life

W-K-M Non-Lubricated SAF-T-SEAL Gate Valve

Line pressure powers SAF-T-SEAL's Teflon*-and-metal floating seats and the gate to provide a perfect total-contact seal. These unique seats greatly increase service life over conventional valves. The SAF-T-SEAL Gate Valve provides automatic relief of excessive body pressure and is ideal for block and bleed service. Maintenance is minimized, but when necessary the valve may be easily repaired on the line. The SAF-T-SEAL Gate Valve is available in sizes from 2" to 42" in a range of working pressures from ASA 150 lbs. to ASA 900 lbs. Send for Catalog WS 1061. W-K-M Division of ACF Industries, Inc., P. O. Box 2117, Houston, Texas.

*DuPont's tetrafluorethylene resin

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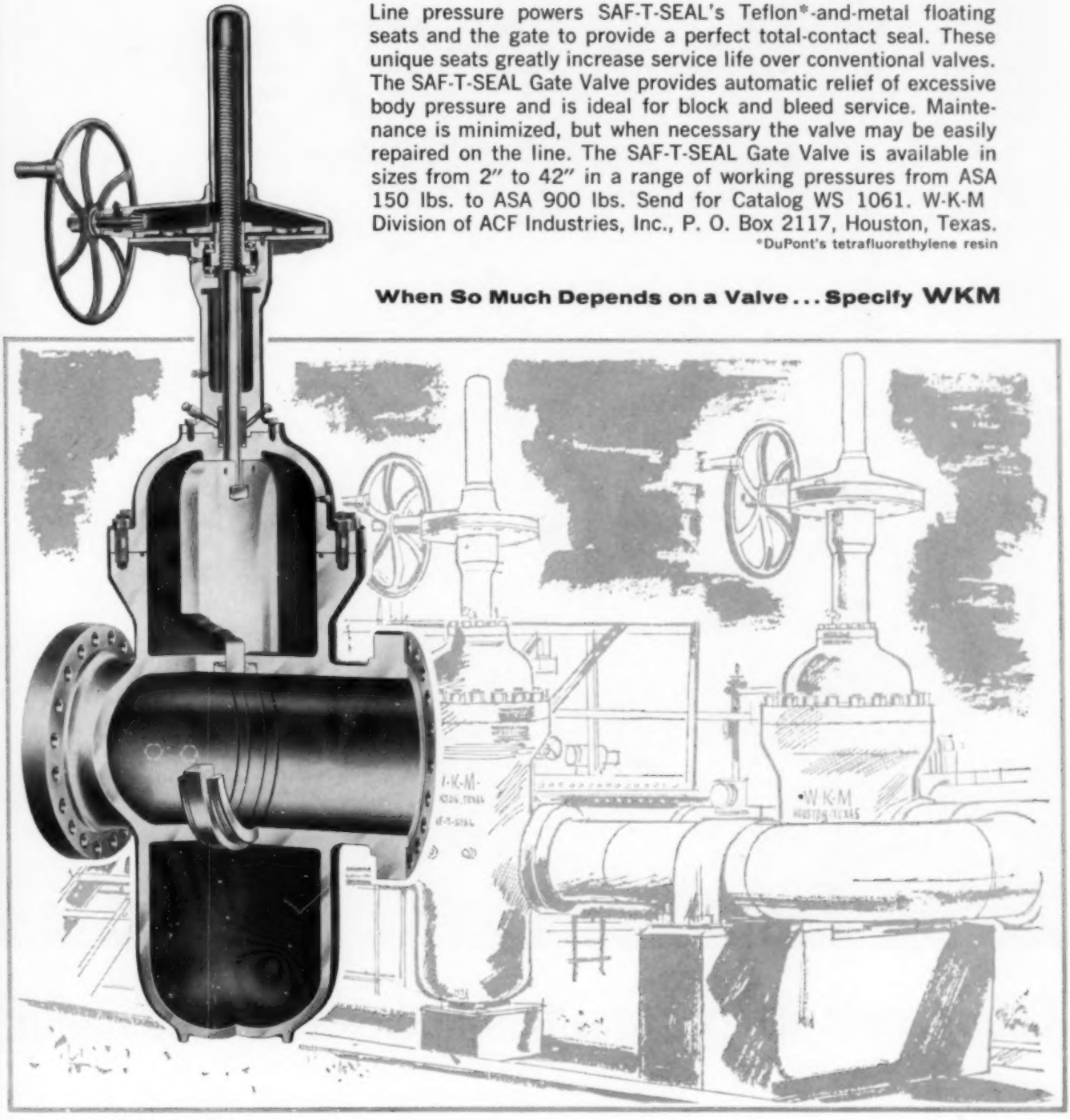

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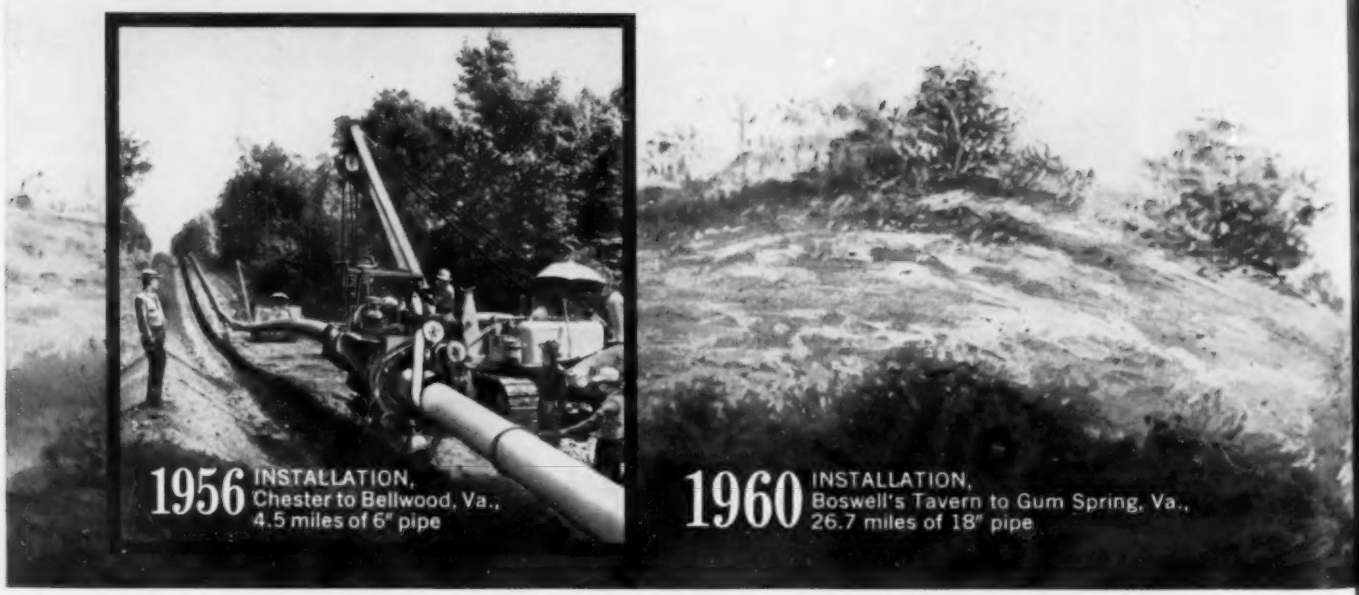
1956 INSTALLATION,
Chester to Bellwood, Va.,
4.5 miles of 6" pipe
1960 INSTALLATION,
Boswell's Tavern to Gum Spring, Va.,
26.7 miles of 18" pipe

Commonwealth Natural Gas makes repeated use of

Officials of Commonwealth Natural Gas Corporation of Richmond, Va., were impressed in 1956 with the many advantages of Polyken coating protection. With confidence based on the cathodic protection needs of their Polyken tape-coated 1956 Bellwood line (*inset photo*), they put this coating to work two years later on their Chester to Petersburg, Va., line (12 miles of 18" pipe). In 1959, *more* Polyken coating . . . Waverly to Ivor, Va., (15.8 miles of 12" pipe). And most

Polyken® coating on strength of past performance

recently, the line from Boswell's Tavern to Gum Spring (*main illustration*).

It stands to reason that repeated use is founded on first-hand satisfaction and trust. Many discriminating companies make Polyken protection their standard specification because of its dependable performance. Get full details on Polyken performance and economy from your representative, or write Polyken Sales Division, 309 West Jackson Boulevard, Chicago 6, Ill.

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THE KENDALL COMPANY
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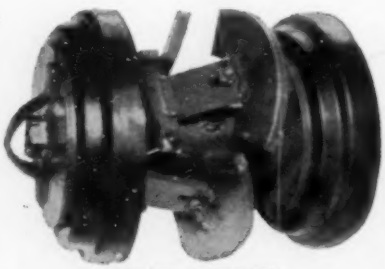
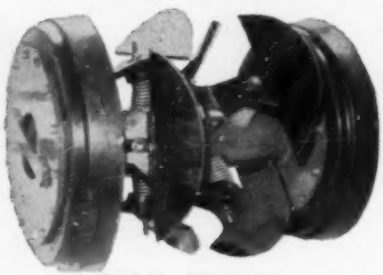


TYPE HI—6" TO 18"



TYPE HI—20" TO 36"

TYPE HI—6" to 36"

The latest development in pipe cleaning tools.

CONSTRUCTION

These springs extend through the center of the unit to blades on the opposite side of the unit which gives it a maximum of flexibility. The heavy springs on this unit help to keep it centered in the pipe supporting its own weight which will give far greater cup life.

DESIGN

This unit is ideal for first run on new construction, or for extremely corroded pipelines.

PIPELINE CLEANERS CO.

FORT MADISON, IOWA
PHONE DRake 2-2051

PROPOSED PIPE LINE CONSTRUCTION

Here in convenient summary form is Pipe Line Industry's listing of company, line size, length, service, location and project status.

* indicates that this item is a new entry or that status of this project has changed since last appearance.

U.S.

* **Anadarko Production Co.**, 83 miles, 12-inch, gas, Spivey-Grabs-Basil field to El Dorado, Kan., planned.

Algonquin Gas Transmission Co., Boston, 25 miles, 20-inch; 8 miles, 8-inch, gas, and 12,000 hp addition in Massachusetts, $6 million, FPC Authorization.

Arkansas Louisiana Gas Company, Shreveport, La., 58 miles, 2-6-inch, gas, planned.

Border Gas Transmission Company, 300 to 400 miles, gas, gathering, in South Texas, $10 million, planned.

Buckeye Pipe Line Co., New York, 42 miles, 8-inch, products, Flint to Bay City, Mich., $1.7 million, planned.

California Gas Transmission Company, Los Angeles, (subsidiary of Tennessee Gas Transmission Company), 292 miles, 20-34-inch gas, from Mexico-California border near Mexicali, to Los Angeles and 10,000 hp. to tie into Texas Mexico-California line, $50 million, before FPC and California Public Utilities Commission.

Coastal States Gas Producing Co., Corpus Christi, Texas, 60 miles, 10-inch, gas, gathering, La Salle and Frio counties, Texas, before FPC.

60 miles, small diameter, gas gathering line, to tie in with system under construction and extend to Pearsall County, Texas, planned.

Coastal Transmission Corp., Houston, 71 miles, 3 to 10-inch, gas, laterals; 5,500 hp in stations at Port Lavaca, Texas, and Eunice, La., and additional 1,500 hp at Robstown, Texas, $7.2 million, FPC examiner authorization.

Colorado Interstate Gas Co., Colorado Springs, 140 miles, 34-inch, gas, Green River, Wyo.,-to-Provo, Utah; 109 miles, 26-inch, Texas Panhandle to southeastern Colorado, 136 miles, 34-inch, southeastern Colorado-to-Pueblo, Colo.; 107 miles, 30-inch, Pueblo-to-Denver, $91 million, FPC conditional authorization.

Colorado Oil & Gas Corp., Denver, 400-miles, gas, from Gubik field to Fairbanks, Alaska, planned.

Columbia Gulf Transmission Company, Houston, 97 miles, 30-inch, loops in Kentucky, Tennessee, Mississippi and Louisiana; 29 miles, 12-inch lateral in Louisiana, $15 million, before FPC.

Dixie Pipeline Company, Tulsa, 1,000 miles, LPG, Mont Belvieu, Texas, to North Carolina, $35 million, planned.

El Paso Gas Supply Company, El Paso, Texas, 228 miles, 30-inch, gas, main, Live Oak to Sutton County, Texas, $30 million, before FPC.

El Paso Natural Gas Company, El Paso, 199 miles, 30-inch, Permian-San Juan crossover loop, before FPC.

17 miles, from Pacific Gas Transmission Co. facilities to near Spokane, Wash., before FPC.

34 miles, 20-inch, Puckett to Goldsmith, before FPC.

23 miles, 20-inch, Goldsmith to Eunice-Plains line, before FPC.

9 miles, 20-inch, Goldsmith-Plains loop, before FPC.

43,600 hp in new and existing stations in Texas, Oklahoma, New Mexico and Utah, before FPC.

400 miles, 34-inch, Salt Lake City, Utah, to California border, FPC conditional authorization.

* 35 miles, 8-inch, gas, to deliver gas to Southern Union Gas Company in Dallas, $1 million, before FPC.

Equitable Gas Company, Pittsburgh, Pa., 31 miles, 16-inch, and 26 miles, 20-inch, in West Virginia and Pennsylvania, $5 million, before FPC.

Hope Natural Gas Company, Clarksburg, W. Va., 20 miles, 20-inch, gas, in Lewis, Ritchie and Pleasants counties, W. Va., $2 million, FPC authorization.

Houston Texas Gas & Oil Corp., St. Petersburg, Fla., 235 miles, 2 to 6-inch, gas, laterals; 20,000 hp in five new stations; $16 million, FPC examiner authorization.

Kansas-Nebraska Natural Gas Company, Hastings, Neb., 165 miles, 2-8-inch, gas, extension from Alliance, Neb., to Chadron, Crawford, Hemingford, Hay Springs, Gordon and Rushville, Neb., before FPC.

45 miles, 2-3-inch, gas, in Kansas, approved by Kansas Corporation Commission.

2,000 hp addition at Scott City, Kan., FPC approval authorization.

2,500 hp addition at Holcomb, Kan., before FPC.

Lone Star Gas Company, Dallas, 47 miles, gathering lines in Palo Pinto, Erath and Stephens counties, Texas, planned.

Long Island Pipeline Company, New York, 75 miles, 20-inch, products, Linden, N. J., to Long Island, N. Y., $30 million, planned.

Lo-Vaca Gathering Co., 230 miles, 6-20-inch, gas, gathering, Live Oak to Lavaca County, Texas, planned.

Continued on Page 84

Photo courtesy of Coast Paint & Lacquer Company, Houston

VERSAMID®-Epoxy internal coatings promise important boost in pipeline pay-off

Protection of pipeline interiors on test lines of several major companies has established the use of thin film coatings as a sound investment. In addition to yard-coating of new pipe shown here, field application in pipelines already in service has proven quite practical . . . using compressed air driven "pigs."

Not only do these coatings reduce maintenance and repair costs, their unusual corrosion resistance eliminates contamination of "freight" being transported. In oil lines, the coating also reduces paraffin deposition.

General Mills Versamid-epoxy resins are used to produce coatings that adhere tenaciously to the pipe . . . even badly corroded lines, when cleaned of loose surface scale. Versamid resins are nontoxic . . . safe to handle without precautions.

A major side-line benefit is the increased throughput on coated lines . . . up to 8% more gallons-per-minute . . . with *reduced* line pressure. The tough yet flexible and resilient Versamid-epoxy coatings also resist abrasion to boost pipeline life. For complete details on the money-making possibilities with Versamid-based internal pipeline coatings, call your General Mills Chemical man, or write direct to:

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For more data on advertised products, use Readers' Service Cards, last page.

PROPOSED CONSTRUCTION

continued

Matador Pipe Line Corp., Denver 175 miles, crude, from Bottineau, Burke and Renville counties, N. D., to Cromer, Man., Canada, $4 million, proposed.

Michigan Wisconsin Pipe Line Company, Detroit, 88 miles, gas, 3,000 hp, take gas from Northern Natural at Janesville, Wis., before FPC.

Mid-America Pipe Line Co., 405 miles, 10-inch, LPG, Superior, Wis., to Chicago, $12 million, considered.

106 miles, 6-inch, LPG, extension from Whiting to Ogden, Iowa, planned for 1961.

100 miles, LPG, extension from Ogden City, to Charles City, Iowa, planned for 1962.

Monterey Gas Transmission Company, Houston. 216 miles, 30-inch, gas, Clear Lake, Texas, to Alexandria, La., planned.

* **Mountain Fuel Supply Co.,** Salt Lake City, 103-mile, 20-inch, gas Uintah Basin to Clear Creek, Carbon County, Utah, before Utah Public Service Commission.

Natural Gas Pipeline Company, Chicago, 285 miles, 30-inch; 60 miles, 36-inch and 22 miles, 8-inch, gas, and 64,200 hp, in Illinois, Texas, Arkansas, Kansas, Nebraska, Iowa and Missouri, $52 million, before FPC.

New Haven Pipeline, Inc., products line, New Haven, Conn. to Springfield, Mass., $2.5 million, planned.

Niagara Mohawk Power Corp., 122 miles, 12-inch, Watertown and Massena, N. Y., contract let to Fulghum Contracting Corporation pending FPC approval.

Northern Natural Gas Company, Omaha, 50 miles, gas line, 2,000 hp, before FPC.

99 miles, gas, 4,660 hp, $8.9 million, before FPC.

233 miles, gas, 14,000 hp, to connect to Michigan Wisconsin system at Janesville, Wis., $23 million, before FPC.

Northern Gas Products Co., (subsidiary of Northern Natural Gas Co.), 350 miles, 8-inch, LPG, Bushton, Kan., to Des Moines, Iowa, $12 million, planned.

Northwestern Refining Co., crude gathering system, Rival and Lignite fields, North Dakota, $625,000, Public Service Commission approval.

Ohio Fuel Gas Co., 59 miles, gas, 4-24-inch main lines, in Belmont, Carroll, Cuyahoga, Fairfield, Logan, Lorain, Marion, Muskingum, Stark and Wayne counties, Ohio, $5.1 million, planned.

Panhandle Eastern Pipe Line Co., Kansas City, 305 miles, 30-inch, 40 miles, 26-inch, gas, loops, and 43,000 hp, and gathering facilities, $60 million, before FPC.

200 miles, 22-24-inch, gas, lateral, from Elk City, Okla., to Haven, Kan., $15. million, before FPC.

Phillips Pipe Line Co., Bartlesville, Okla., 75 miles, main line, 85 miles, gathering crude, from Camrick field, Gray, Okla., to Phillips, Texas, planned.

Southern California and Southern Counties Gas Cos., Los Angeles, 93 miles, 34-inch, California-Nevada border to Newberry, Calif.

St. Lawrence Gas Company, Inc., Ogdensburg, N. Y., 75 miles, gas, main, United States-Canadian border to Ogdensburg, N. Y., $3.4 million, FPC examiner approval.

SunOlin Chemical Company, Philadelphia, 6,000 feet, ethylene line, under Delaware River, Claymont, Penn., to Penns Grove, N. J., $2 million, planned.

Tennessee California Gas Transmission Company, (subsidiary of Tennessee Gas Transmission Co.), 100 miles, 26-inch, gas, gas fields in South Texas to Texas-Mexico border near Reynosa, before FPC.

Tennessee Gas Pipeline Co., Houston 191 miles, 30 and 36-inch loops, in Ohio, Pennsylvania and New York, 72 miles of gathering lines and 43,600 hp in five stations, $46 million before FPC.

158 miles, 36-inch, gas, loops in Mississippi and Louisiana, FPC authorization.

21 miles, 16-inch, 2 miles, 12-inch, gas, Louisiana coast, Vermilion blocks 46 and 64, $3 million, before FPC.

50 miles, 10-16-inch, gas, offshore Louisiana, FPC authorization.

Texas Eastern Transmission Corp., Shreveport, La.

66 miles, 30-inch, gas, loops, between Vidor, Texas, and Lambertville, N. J., and 33,710 hp in four existing stations, $17.5 million, temporary FPC authorization.

165 miles, 20-inch, gas, West Monroe, La., to Kosciusko, Miss.; 128 miles, 30-inch, loops, between Kosciusko and Lambertville, N. J., and 37 miles, laterals in New Jersey, 51,000 hp., $55.2 million, before FPC.

144 miles, gas, 46,300 hp. $27.8 million, for 1962, before FPC.

* **Texas Eastman Co.,** Longview, Texas, 280 miles, 6-inch, products, Houston to Longview, planned.

Texas Gas Transmission Corp., Owensboro, Ky., 96 miles, 26-30-inch, gas loops, Louisiana, Arkansas, Mississippi, Tennessee, Kentucky and Indiana; 50 miles, 8 and 16-inch extension into Terrebonne, La., producing area, $16.8 million, before FPC.

Transcontinental Gas Pipe Line Corporation, Houston.

211 miles, 36-inch, and 69 miles, 30-inch, loops and additional 32,040 hp, in Texas, Louisiana, Mississippi, Alabama, Georgia and South Carolina, $52 million, FPC approval.

163 miles, 36-inch, gas, loops, in Louisiana, Alabama, Mississippi, Georgia, North and South Carolina, Virginia, Maryland and Pennsylvania, 10,500 hp, $30 million, before FPC.

13 miles, 24-inch and 18 miles, 20-inch loops, Louisiana, FPC authorization. 14 miles, 16-inch laterals, 1-mile, 12-inch lateral, Louisiana, $2.1 million, FPC authorization.

29 miles, 20-inch, gas, and 2,500 hp, in South Texas to take gas from South Texas Natural Gas Gathering Co., $2.4 million, FPC authorization.

Trans-Southern Pipeline Corp., Houston, 1,080 miles, 12-inch, LPG, from Mont Belvieu, Texas, to Danville, Va., and 215-mile spur line from Atlanta to Georgia-Florida border, $63 million, planned.

* **Trunkline Gas Company,** Houston, 97 miles, 30-inch, loops, between Longville, La., and Tuscola, Ill., 27 miles, supply laterals, and two 6,000 horsepower compressor stations, before FPC.

* 74 miles, 26-inch, gas, Longville to Cow Island, La., 24 miles, 18-inch, Cow Island to Gulf shore, and 24,000 horsepower, $18 million, FPC authorization.

* **United Gas Pipe Line Co.,** Shreveport, La., 59 miles, 36-inch, gas, lateral, between Bastian Bay and Plaquemines Parish, La., $17 million, temporary FPC authorization.

217 miles, 30-inch, Lafayette to Monroe, La., $32 million, temporary FPC authorization.

Valley Gas Transmission, Inc., Houston, 55 miles, 3 to 8-inch, gas, gathering, in Hidalgo, Brooks, Starr and Jim Wells counties, Texas, $15 million, before FPC.

West Shore Pipe Line Co., 285 miles, 10-16-inch, products, East Chicago, Ind., to Green Bay, Wis., $22 million, contract let to **Houston Contracting Co., Midwestern Contractors, Contracting and Material, Somerville Construction Co.** and **Panama-Williams Corp.**

International

ACT Oils, Ltd., Montreal, 400 miles, crude, Dawson Creek, B. C., to Bella Coola, B. C., before B. C. Government.

Ajax Alberta Pipeline Ltd., 28 miles, 10-inch, gas, main, Morinville to Westlock, Alta., planned.

Assistencia de Oleodutos du Petrobras, Rio de Janeiro, 280 miles, 12-inch, crude, Rio de Janeiro to Belo Horizonte, Brazil, planned.

Abu Dhabi Marine Areas Ltd., (British Petroleum Co. and Compagnie Francaise Des Petroles) 20 miles, 18-inch, crude, from Umm Shaif offshore oilfield to Das Island, Persian Gulf, planned.

Barnabos Group (Italian Interests), crude line from Venice, Italy, to Insbruck, Austria, with extension to Munich, Germany, planned.

Bituminous Oil Pipeline Co., Calgary, 250 miles, crude, from Athabasca tar sand plant in northeastern Alberta to Edmonton, approved.

British American Oil Co., Ltd., Toronto, 125 miles, gas, Pincher Creek fields to Calgary, Alta., before Alberta Public Utilities Board.

Burmah Oil Co., Ltd., 850 miles, crude, 20 inch, from Nahorkatiya to Calcutta, India. Contract let on 250 miles to Mannesmann-Saipem.

Cartier Gas Corp. (St. Maurice Gas, Inc., and Consumers Gas Co., Toronto), 170 miles, gas, Montreal to Quebec City, planned.

Consolidated Gathering Systems, Ltd., Calgary, 198 miles, crude, Sturgeon field to Edmonton, planned.

Foothills Pipe Lines Ltd., 1,300 miles, LPG, from Alberta-Saskatchewan border to Chicago, tie-in with Westalta Products Pipeline proposed system in Alberta, $100 million, before Alberta Board of Public Utilities Commissioners.

Gas del Estado, Buenos Aires, 1,050 miles, 30-inch, gas, Comodoro Rivadavia field to Buenos Aires, $380 million, bids submitted for design and construction by Texas Eastern Transmission Corp., ENI, and an Argentine firm.

Gas Trunk Line of British Columbia, Vancouver, 250 miles, 30-inch, gas, main, Fort Nelson to Taylor, B. C., planned.

Gases Naturales de Colombia, S.A., 140-mile, 10-inch, gas, Cicuco field to Barranquilla, Colombia, underway.

Gasversorgung Sueddeutschland, 180 miles, gas, Mannheim to Karlsruhe to Kehl and Ulm, $20 million, planned.

Hughenden Pipeline, 125 miles, products, Dick Lake gasoline plant to Hughenden Region, Alta., planned.

Hydrocarbons Pipeline, Ltd., Winnipeg, Manitoba, 880 miles, 6-8 inch, products, from Edmonton to Winnipeg, $35 million, partial authorization.

Independent Pipe Line Co., 2,019 miles, 34-36-inch, crude, Edmonton to Montreal, 23,000 pump horsepower, $395 million, before Borden Commission.

Interprovincial Pipe Line Company, 350-mile extension from Toronto to Montreal, looping line from Edmonton to Toronto, crude, $240 million, considered, products pipe line, Superior, Wis., to Chicago, considered.

* 90-mile, crude, Hamilton, Ont., to Buffalo, N. Y., before National Energy Board of Canada.

Mid-Continent Pipe Lines, Ltd., 1500-mile, 30-inch crude, Edmonton to Chicago, planned.

Naphtha Israel Oil Co., 75 miles, 6-inch, gas, Rosh-Zohar field to Ashdod Yam on Mediterranean planned.

National Iranian Oil Co., 146 miles, 6 inch, crude, from Azna to Isfahan, Iran, $5 million, planned.

Northern Alberta Pipe Lines, Ltd., Edmonton, Alta., 110 miles, 10-inch, gas, main, Lac La Biche to Edmonton, $3 million, planned.

Northern Pipe Line Company, 153 miles, 16-inch, crude, from Regina, Saskatchewan, to Clearbrook, Minn., $10 million, planned.

* **Oasis Oil Co. of Libya,** (Amerada, Continental, and Ohio Oil Co.) 86 miles, 30-inch, Dahra field to Es Sider, Libya; 36 miles, 20-inch, Mabruk to point between Es Sider-Dahra, contracts let to **Libyan Engineering and Construction Co.** and **Arabian Bechtel Corp.**

Peace River Oil Pipe Line Co., Ltd., 70-mile, crude, Swan Hills to Iosegun Junction, approved.

Petroleos Mexicanos, 4, 6 and 8-inch, products, Mexico City-Puebla to Cuernavaca, planned.

1,240 miles, 34-inch, gas, Reynosa to Mexicali, Mexico, $160 million, negotiating with Tennessee Gas Pipeline Company for design and construction of the line.

360 mile, 12-inch, products, Minatitlan to Puebla and Mexico City, planned.

Products, Guadalajara to Tepic, planned.

Products, Aguascalientes to Zacatecas, planned.

Continued on Page 86

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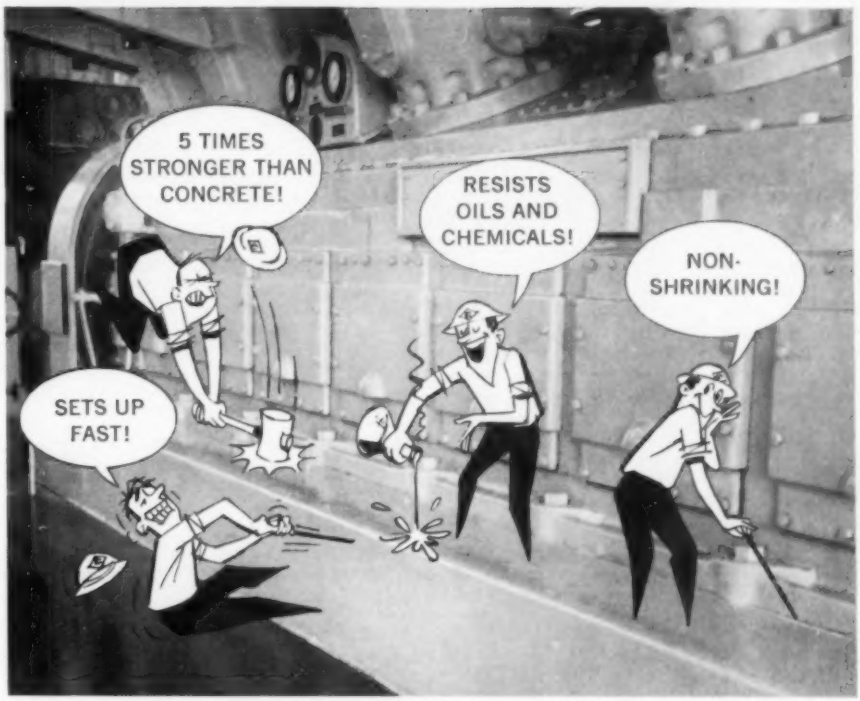

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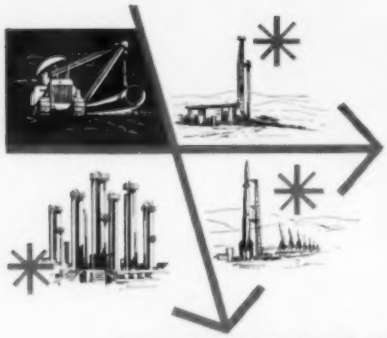
For more data on advertised products, use Readers' Service Cards, last page.



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PROPOSED CONSTRUCTION

continued

6-inch, products, Guaymas to Ciudad Obregon, considered.

8-inch products, Guaymas to Hermosillo, considered.

8-inch, gas, Tierra Blanca to Veracruz.

Gas, Ciudad Carmen to Ciudad Pemex.

8-inch, crude Comalcalco to Minatitlan.

Crude, Minatitlan to Salina Cruz, contingent on proposed refinery on Pacific Coast.

149 miles, 10-inch, products, Ciudad Pemex to Minatitlan, planned.

181 miles, 4-inch, products, Mexico City to Salamanca, planned.

Pipelines of Puerto Rico, Inc., 95 miles, 8-inch, products, Penuelas to San Juan, Puerto Rico, approved.

Provincial Pipe Lines, Ltd., 700 miles, 3-16-inch, hydrocarbon line gathering system in Alberta, $25 million, before Alberta Oil and Gas Conservation Board.

Qatar Petroleum Company, Qatar, 60 miles, 6-10-inch, gas, Dukhan to Doha, Qatar, contract let to Mothercat Co., Ltd.

Quebec Gas Transmission Lines, Inc., Montreal, 300 miles, gas, main, Quebec to Montreal, planned.

Rangeland Pipe Line Company Limited, 111 miles, 8-inch, crude, southeastern Alberta to Calgary, $3 million, planned.

Saskatchewan Power Corp., 179 miles, 4-6-8-inch, gas, planned.

* **Societa Nazionale Metanodotti,** 650 miles, 18-inch, crude, Genoa to Milan-Cremona-Torino, Italy, and Aigle, Switzerland, with extension to Karlsruhe and Munich, Germany, contract let on Italian portion to Saipem.

Societe du Pipe Line Sud-European, Paris, 432 miles, 34-inch, crude, port of Lavera to Strasbourg, with lateral extending 40 miles to Karlsruhe, Germany, approved by French cabinet.

Soc. Siciliana Metanadotti, gas line from Hassi R'Mel field in Algeria through Tunisia, across Mediterranean to Sicily and into Italy, considered.

Standard-Vacuum Oil Company, 60 miles, 8-inch, gas, main, in South Sumatra, considered.

Ste. d-Etudes de Pipeline Intercontinetaux, Paris, 1,400 miles, 30-40-inch, gas, from Hassi R'Mel field in central Algeria across Mediterranean, through Spain, France and into West Germany, considered, Fish International Corporation making engineering and feasibility studies.

Sui Gas Transmission Co., Multan, Punjab, India, 145 miles, 8-inch, gas, from Sylhet to Dacca, East Pakistan, $9 million, considered.

130 miles, 16-inch, gas, main line, Multan to Lyallpur, planned.

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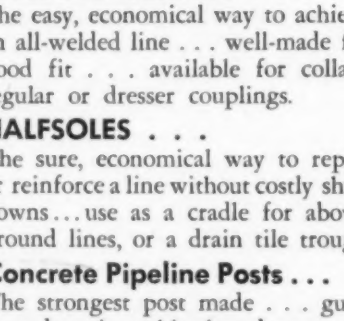

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Syrian Pipeline, Damascus, 500 miles, crude, from Karshuk field, Syria, to Mediterranean, planned.

300 miles, products, from Homs to tank farms in Damascus, Aleppo and Latakia, planned.

Trans-Prairie Pipelines, Ltd., Edmonton, crude line, from Weyburn field to Regina-Moose Jaw areas, $5 million, considered.

Trunk Pipelines Ltd., London, 70 miles, products, Canvey Island to Denham, Buckinghamshire, bill before Parliament. Extension of line from Denham to Birmingham, planned.

Westalta Products Pipeline Ltd., 900 miles, LPG, from Northern Alberta to Saskatchewan border, to deliver hydrocarbons to Foothills Pipe Lines, $40 million, before Alberta Board of Public Utilities Commissioners.

Williams-McWilliams Industries, Inc., New York, 441 miles, 6-inch, crude, Villa Montes, Bolivia, to Villa Hayes, Paraguay, considered.

* **Westcoast Transmission Co.,** 505 miles, 12-inch, crude, Taylor to Kamloops, B.C., $30 million, contracts let to **Dutton-Williams Brothers Limited** and **Canadian Bechtel Limited.**

FPC Grants Tennessee Temporary Authorization

Temporary authorization was granted to Tennessee Gas Transmission Company for construction of facilities to take gas from Vermilion Parish and offshore Louisiana.

Tennessee plans to lay 33 miles of pipe line and appurtenant facilities at a cost of about $3.4 million. The line would enable TGT to take about 382.5 billion cubic feet of gas for its system. Gas will come from Lac-Blanc field Vermilion Parish, and West Cameron Block 68 and Grand Isle Block 47.

Westcoast Subsidiary Plans 67-Mile System

Saratoga Processing Company Limited, a subsidiary of Westcoast Transmission Company, plans to construct a 67-mile gas gathering system in Savanna Creek field in Alberta. The company will deliver 50 Mcf of gas daily to the Alberta-California pipe line under construction.

Canadian Betchel Limited will handle engineering, and construction on the line which will consist of 43 miles of 16-inch and 24 miles of 4-10-inch.

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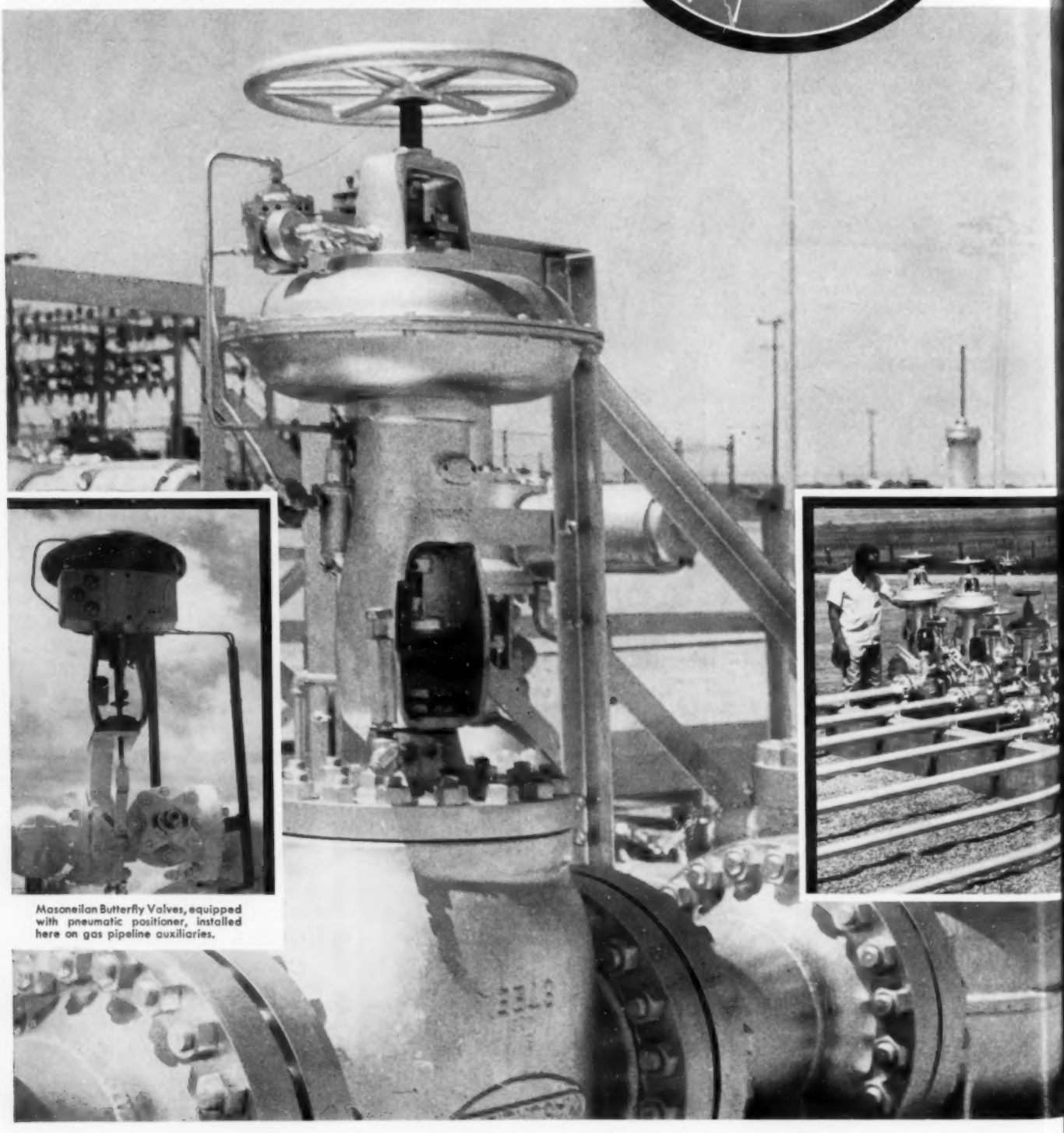

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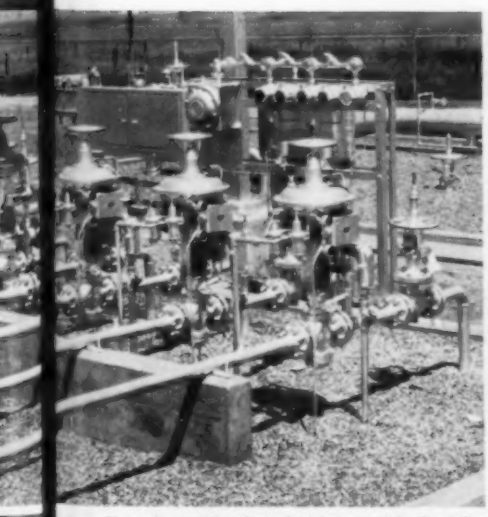

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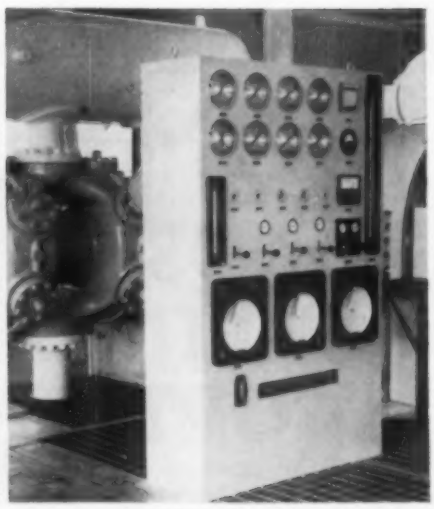

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MN 1-9

Canada to Buffalo, N.Y., Crude Pipe Line Planned

Plans for a 90-mile crude line from Hamilton, Ont., to Buffalo, N.Y. have been filed with the Canadian National Energy Board by Interprovincial Pipe Line Company.

Construction of such also depends upon the result of current hearings in Washington on import studies. Interprovincial's line would serve Ashland Oil & Refining Co.'s 30,000 barrel capacity refinery with the possibility of adding Mobil Oil Company's 31,000-barrel refinery.

Coastal States Lets Contract to Adair

Adair Pipeline Company has been awarded a contract by Coastal States Gas Producing Company for 32 miles of 10-20-inch gas lines in Texas.

The line will run from near Hebbronville to Zapata, Texas.

Ecuador Pipe Line Under Construction

Construction is underway on a 210-mile products pipe line Ecuador from the port of Duran to Quito. Initial capacity will be 5,000 barrels per day.

Northern Natural Lets Contract on 200 Miles

Northern Natural Gas Company has awarded contract for construction of 200 miles of 20 and 26-inch gas lines in Michigan and Wisconsin.

Northern's work includes 120 miles in Iowa which was awarded to R. H. Fulton & Company, and 82 miles of 20-inch in Wisconsin which will be laid by Panama, Inc.

Humble-Interstate Merger

Plans have been announced for the merger of Humble Pipe Line Company and Interstate Oil Pipe Line Company, subsidiary of Standard Oil Company (New Jersey).

Humble Oil will be owner of all stock of the new pipe line company with headquarters in Houston. Interstate's president, Phelan H. Hunter will become president and W. S. Spangler, president of Humble Pipe Line, will be executive vice president.

The new company would have about 12,500 miles of lines serving 930 areas in five states. In daily thruput capacity, the system would be the largest in the nation with about 1.2 million barrels per day capacity.

Americans to Visit Russia

Eight United States gas experts will visit the Soviet Union for a month beginning July 2. A visit by Russian representatives for May had been postponed and will be conducted later, probably in September.

The visits will be the first under a 1959 agreement providing for scientific and cultural exchanges.

Americans making the trip will include Baxter D. Goodrich, senior vice president, Texas Eastern Transmission Corp.; William R. Connole, Washington attorney and former FPC Commissioner; E. H. Smoker, president, United Gas Improvement Company; Henry A. Eddins, president, Oklahoma Natural Gas Co.; Fred W. Batten, vice president, Natural Gas Department, Phillips Petroleum Co.; Paul W. Kraemer, vice president, Minneapolis Gas Co.; and Samuel J. Cunningham, senior research engineer, AGA.

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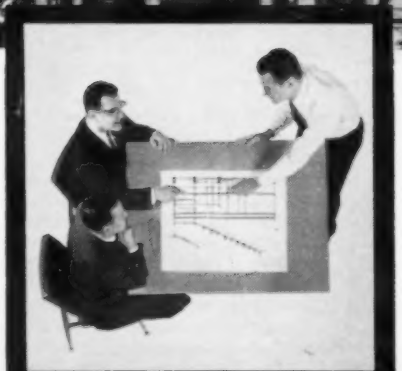

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What's Happening among MEN in the INDUSTRY

German Representatives Visit U.S. Installations

C. S. Stackpole, second from left, managing director of the American Gas Association, was a host to German gas industry representatives during the visitors two-week inspection tour of the United States pipe line and utility companies. The foreign inspectors investigated economic and technical aspects of the natural gas industry. Pictured, from left to right, are Jurgen Stech, director, Technischen Werke der Stadt Stuttgart; Stackpole; Dr. Heinrich Kaun, general director of Technischen Werke der Stadt Stuttgart and past president of Union of German Gas and Water Works, and Dr. J. P. Kazickas, foreign director, Saljoan Coal & Coke Corp., New York City.

Algonquin Gas Transmission Company has named **Robert J. Dunbar** vice president. He has been with the company since 1952. Dunbar served as measurement superintendent, pipe line superintendent and general superintendent. Prior to joining Algonquin, he had been assistant chief engineer of Commonwealth Natural Gas Corporation.

E. O. N. Williams has been elected president of the **Liquefied Petroleum Gas Association.** After serving one year as first vice president, he succeeds **R. J. Munzer.** Williams is president of **Bottled Gas Corp.,** and a director of Commonwealth Natural Gas Corp.

W. A. Schuette, president of **Petrolane-Hausgas Inc.,** was named first vice president. **John A. Storm, Sinclair Oil & Gas Company,** is second vice president and **Norman A. Evans, Pressed Steel Tank Co.,** was named treasurer.

Alex Carameros, El Paso Natural Gas Company, has been named chairman of the operations committee of the gas turbine power division of the American Society of Mechanical Engineers. El Paso's safety director, **Tom J. O'Donnell,** has been selected chairman of the accident prevention committee of the Pacific Coast Gas Association for 1961.

L. R. Johnston has been named labor relations advisor in **Gulf Oil Corporation's** Domestic Employe Relations Department at Houston. He will advise the company's operating elements on labor relations matters. Since 1959, he has been serving as director of the labor relations and benefits divisions at Gulf's Port Arthur refinery.

Arkansas Louisiana Gas Company and **MidSouth Gas Co.** plan a merger in which Arkla would absorb MidSouth. Stockholders of MidSouth would receive one share of Arkla common stock for two shares of MidSouth. The merger is subject to approval by stockholders and regulatory agencies.

Natural Gas Pipeline Company of America has named **R. E. Hayes** general superintendent, and **J. W. Allen** assistant general superintendent of the Data Processing and Disbursements Division. **M. M. Saidikowski** has been appointed general superintendent, Accounting Division. Both are newly-created divisions.

William C. Keefe has been named vice president and secretary of **Panhandle Eastern Pipe Line Company** and its subsidiary, **Trunkline Gas Company.** Keefe joined Panhandle Eastern in 1950, and was named secretary in 1956.

Stone & Webster Engineering Corporation has elected three new vice presidents. **C. G. Davis,** a construction manager; **T. A. Fearnside,** manager of engineering, and

F. R. Stevens, labor relations consultant and former personnel manager will fill the posts.

Davis has been with the company since 1937. Fearnside joined the firm in 1940, and Stevens has been associated with Stone & Webster since 1941.

Fred Zapffe has joined **Foor Engineering Company** as chief engineer. He had been with Lone Star Gas Company for 21 years. At Lone Star he had been in charge of design of compressor and gas processing facilities. He will continue his design activities in his new capacity.

At its board of directors meeting, **Trans-Canada Pipe Lines Limited** named President **James W. Kerr** chairman of the board. Other appointments include election of **Hon. Wilfred Gagnon,** C.B.E. of Montreal, **W. P. Scott** of Toronto, and **Smiley Raborn, Jr.,** Calgary as directors.

James W. Kerr

George W. Woods was appointed vice president and treasurer, and **Donald G. Clark** was named vice president, sales.

Kerr has been president of the company since 1958. Gagnon is chairman of the board of Dow Brewery Limited. Scott is chairman of Wood, Gundy & Company Limited, and Raborn is executive vice president and managing director of Canadian Delhi Oil Limited. Woods has been with the company since 1959. Clark joined Trans-Canada in 1960.

Shell Pipe Line Corporation employes have been awarded first place award in the National Safety Council Contest for 1960 Oil and Gas Pipe Line Group "A". It had the least number of disabling injuries per million man-hours worked. It's the second successive year Shell took the honors. Shell had 1,150 employes in 13 states who worked 2,425,525 man-hours in 1960 with 3 disabling injuries.

John A. Ferguson, who has been executive director of the **Natural Gas Association of America** since 1944, retired to become consultant to the board of directors and assistant to the president. There will be no successor for executive director.

Lawrence H. Gall, general counsel, will assume duties of acting executive director.

The American Gas Association named **Philip B. Sheehan** manager of its newly-organized National Speakers Bureau. Formerly he was assistant to the director of PAR, the AGA promotion, advertising and research program. The Speakers Bureau is a part of PAR public information.

Before joining the AGA in 1960, Sheehan had been coordinator of advertising and promotion with Caloric Appliance Corporation.

Officers and directors of **West Shore Pipe Line Company** have been announced. **P. H. Hunter, Interstate Oil Pipe Line Company** was named president; **W. F. Schoenthaler, Shell Oil Company,** was elected vice president, and **Fred F. Steingraber** of **Pure Oil Company,** was made vice president. **A. C. Hutcheson, Pure Oil Company,** is secretary and **R. F. Sturgis, Jr., Pure Oil Company** becomes treasurer. Assistant secretaries include **S. T. Noell** of

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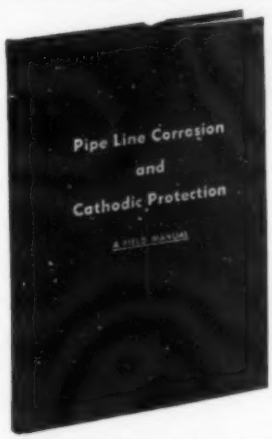

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Pure and **L. V. Dennis** of Interstate Oil. **C. M. Wright,** Shell Oil, becomes assistant secretary and assistant treasurer, and **Frank R. Clark, Jr.,** of Interstate Oil, is assistant secretary and assistant treasurer.

Directors include **C. H. Albitz, R. L. Grogan,** Hunter, **S. L. Jackson, W. L. Kygar, Ben D. Leuty, Jack H. Rice, W. F. Schoenthaler,** Steingraber, and **L. H. True.**

A. S. Munneke has been promoted to electrical and communications supervisor for **Service Pipe Line Company.** Formerly district superintendent on special assignment in the Tulsa office, he succeeds **John Holder** who recently retired.

Trunkline Gas Company's personnel director, **W. C. Fleming, Jr.,** was named chairman of the Southern Gas Association's Employe Relations Section at the annual SGA convention in New Orleans last month.

He will be in charge of a series of round-table conferences to be held during the year. He also will be in charge of the section's program at the 1962 convention in Houston.

Walter S. Hallanan, chairman of the **National Petroleum Council,** has appointed 23 prominent oil and gas representatives to membership on the Council's Committee on Oil and Gas Transportation Facilities.

Monroe E. Spaght, president of **Shell Oil Company** has agreed to accept chairmanship and **Earl E. Ellerbrake, Office of Oil and Gas, U.S. Department of the Interior,** has been named Government Co-Chairman by **Stewart L. Udall, Secretary of the Interior** and Co-Chairman of the NPC.

The transportation committee will undertake a study to determine the petroleum and gas transportation capacities as of January 1961.

Hallanan's appointees include: **Munger T. Ball,** president, **Sabine Transportation Company, Inc.; Jacob Blaustein,** president, **American Trading and Production Corp.; E. D. Brockett,** president, **Gulf Oil Corp.; Orville S. Carpenter,** president, **Texas Eastern Transmission Corp.; James Comerford,** chairman of the board, **Consolidated Natural Gas Co.; George R. Copeland,** president, **Algonquin Gas Transmission Co.; Morgan J. Davis,** president, **Humble Oil and Refining Company; B. C. Graves,** chairman of the board, **Union Tank Car Company; B. I. Graves, B. I. Graves Associates; W. Alton Jones,** chairman of the executive committee, **Cities Service Company; Paul Kayser,** chairman of the board, **El Paso Natural Gas Company; Albert L. Nickerson,** president, **Socony Mobil Oil Company, Inc.; S. F. Niness,** president, **Leaman Transportation Company, Inc.; Ed Parkes,** president, **United Gas Corp.; J. R. Parten,** Houston; **Charles E. Spahr;** president, **The Standard Oil Company (Ohio); P. C. Spencer,** Chairman of the board, **Sinclair Oil Corp.; John E. Swearingen,** president **Standard Oil Company (Indiana),** and **George S. Young,** chairman of the board, **The Columbia Gas System, Inc.**

Vincent M. Brown, assistant secretary-Treasurer of the **National Petroleum Council** will serve as secretary of the committee.

W. D. Walser was promoted to senior vice president and **James E. Ivins** becomes vice president for **Tennessee Gas Transmission Company. Walter Fawcett, Gilbert**

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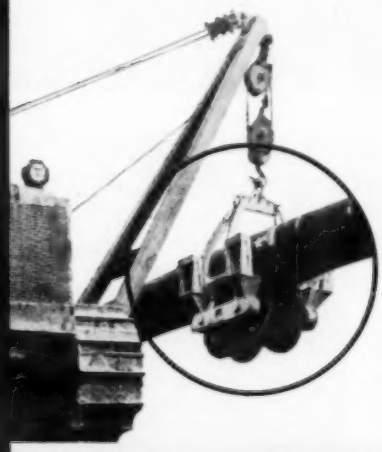

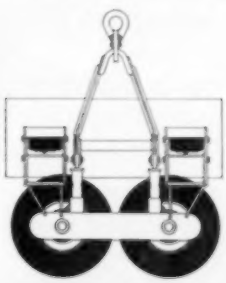

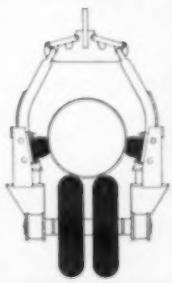

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Fitzgerald and **Leonard F. Lee** were elected vice presidents.

Hulette F. Aby was named corporate secretary replacing Ivins and was named general attorney. He had been assistant general attorney.

The National Association of Corrosion Engineers, Houston Section, has elected officers for 1961. **O. A. Melvin,** consulting engineer for **Carboline Company** was named chairman. **Benton Russell,** president of **Russell and Sharpe, Inc.,** was elected vice chairman and **W. M. Koehler,** senior engineer, **Humble Oil & Refining Company,** was selected secretary and treasurer.

F. F. Deaver has been named manager, crude oil and volatiles supply for **Shell Oil Company.** The appointment follows the recent death of **A. E. Jago,** manager of supply and transportation.

G. Brooks Earnest has been designated the official nominee for 1962 president of the American Society of Civil Engineers. Dr. Earnest is president of **Fenn College,** Cleveland, Ohio. The new term commences at the annual convention of the ASCE in New York in October. Earnest has been with Fenn College since 1951, when he was named dean of engineering. He has been president since 1953.

The American Gas Association has formed an automation committee to coordinate and expand efforts in this area. Previously, various committees have studied automation as it related to specific fields; the new committee's purpose will be to collect and distribute information about automation in the gas industry, to recommend economical application of automation and suggest research projects.

Arthur J. McNair, professor of civil engineering and head of Surveying Department at **Cornell University** was elected president of the American Society of Photogrammetry, it was announced at the twenty-seventh annual meeting in Washington March 19-22. Elected vice president was **James P. Webb** of the **Army Map Service** and **Robert S. Quackenbush, Jr.,** was named second vice president.

I. H. Ricketts has been appointed general superintendent of **Calnev Pipe Line Company.** Ricketts had been project engineer for Williams Brothers Company. Calnev's system, consisting of 248 miles of 8-inch products line, is now under construction. It will provide transportation from refineries in the Los Angeles Basin area to Las Vegas, Nevada. Prior to his service with Williams Brothers, he had been with Continental Pipe Line Company, Platte Pipe Line Company and Cities Service Oil Company.

I. H. Ricketts

Ohio Oil Company has reorganized its Products Distribution division. The divisions include four geographic districts: Ohio, Tri-State, Lake Michigan and Detroit. **A. J. Moorhead,** manager, and **H. E. Bogart,** assistant manager, will handle the Ohio district and headquarter in Findley. In the Tri-State district **W. O. Seabury, Jr.,** manager, and **L. R. Hooper,** assistant manager, will headquarter in Indianapolis, Ind. Lake Michigan is headed by **H. W. Collins,** manager, and **T. C. Buchanan,** assistant manager, with offices in Des Plains, Ill. The Detroit district will be under **I. R. Schiff,** manager and **F. W. Schuessler,** assistant manager, located in Detroit.

A. S. Hagen has been named manager and **C. T. Oxley,** assistant manager of the newly formed Lube Oil and Grease Department. **M. D. King** will be manager and **L. R. Snyder,** assistant manager, of the Products Distribution Division, responsible for all the districts and the new department.

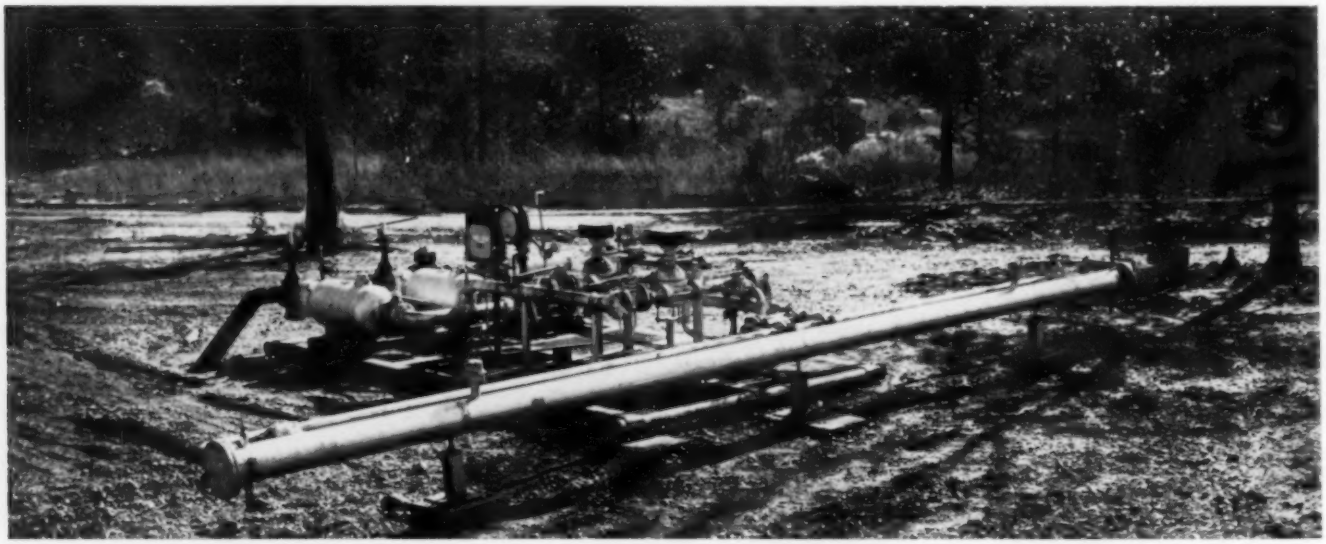
Jim Hayes, 12 year veteran in public relations and publishing fields, has joined the National **LP Gas Council** as Midwest field representative. He had been public relations director for the Michigan Department for the American Legion. He will handle publicity and membership selling assignments.

Stanley B. Finch, executive secretary of **Gas Inc.,** has been named chairman of the board of directors of the newly formed **New York World's Fair Exhibitors Association.** Gas Inc., was formed to represent the gas industries at the fair. The association was organized to represent exhibitors in contacts with management authorities of the fair.

Deaths

Douglas S. Bushnell, 87, retired president of Buckeye Pipe Line Company, died of a heart attack April 20 in Morristown, N.J.

He entered the oil business in 1901, and became president of Buckeye in 1911. He retired in 1938.



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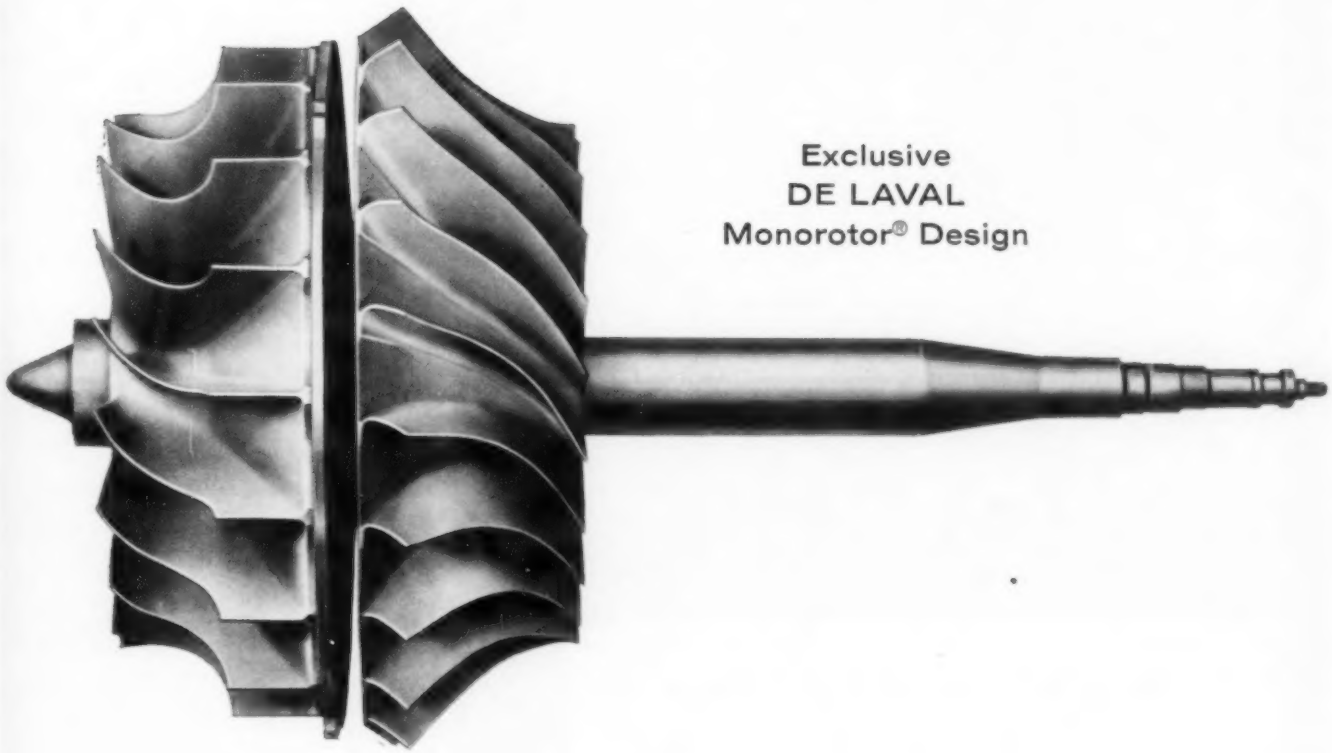

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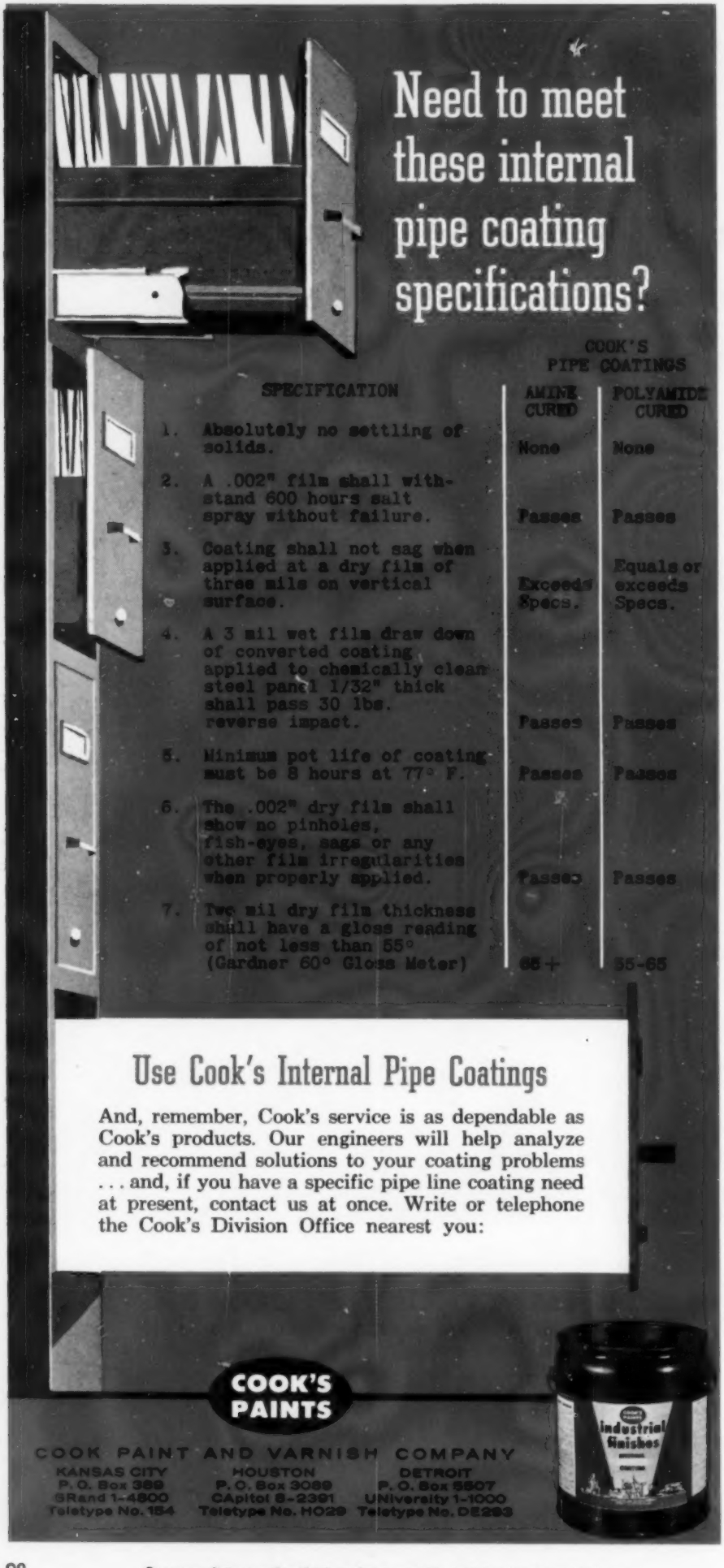
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WHO'S MEETING WHERE

June

Petroleum Electric Power Association, meeting, Mayo Hotel, Tulsa, June 5-6.

ISA, international instrument-automation conference and exhibit, Royal York Hotel, Toronto, Can. June 5-8.

Appalachian Underground Corrosion Short Course, annual meeting, West Virginia University, Morgantown, W. Va., June 6-8.

ASME, summer annual meeting, Statler Hilton Hotel, Los Angeles, June 11-14.

Ninth Annual Technical Writers' Institute, Rensselaer Polytechnic Institute, Troy, New York, June 12-16.

Canadian Gas Association, annual meeting, Grand Hotel, Mackinac Island, Mich., June 20-24.

AIEE, ASME, IRE, ISA, AIChE, second joint automatic control conference, University of Colorado, Boulder, Colo., June 28-30.

September

ISA, Fall Instrument-Automation conference and exhibit, Biltmore Hotel, Memorial Sports Arena, Los Angeles, September 11-15.

Pacific Coast Gas Association, convention and annual meeting, Coronado Hotel, Coronado, Calif., September 13-15.

NGAA, Rocky Mountain Regional meeting, Northern Hotel, Billings, Mont., September 14.

AIEE, petroleum industry conference, New Orleans, September 17-20.

ASME, petroleum division conference, Muehlebach Hotel, Kansas City, September 24-27.

October

AGA, 43rd annual convention, Statler Hilton Hotel and Municipal Auditorium, Dallas, October 1-4.

NACE, Western Region Conference, Hotel Multnomah, Portland, Ore., October 4-6.

NACE, North Central Region Conference, Chase Park Plaza Hotel, St. Louis, October 9-11.

ASME-ASLE, lubrication conference, Morrison Hotel, Chicago, October 17-19.

American Society for Metals, 43rd national congress, Cobo Hall, Detroit, October 23-27.

NACE, South Central Region Conference and exhibition, Shamrock-Hilton, Houston, October 24-27.

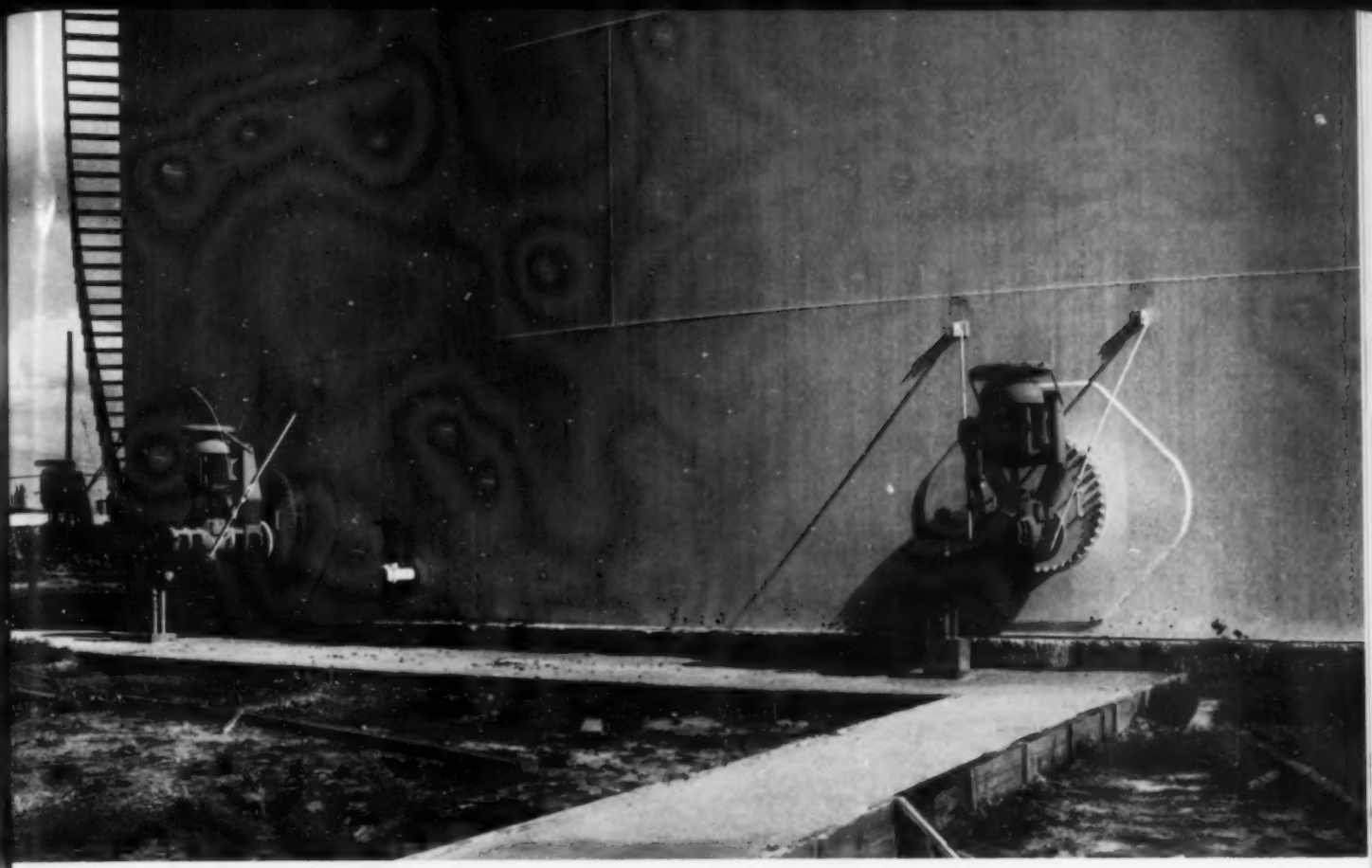
NGAA, Southern Regional meeting, Carlton Hotel, Tyler, Texas, October 27.

NACE, Northeast Region Conference, Hotel Statler, New York City, October 30-November 2.

November

API, annual meeting, Chicago, November 13-15.

NGAA, Panhandle Plains Regional meeting, Herring Hotel, Amarillo, Texas, November 17.



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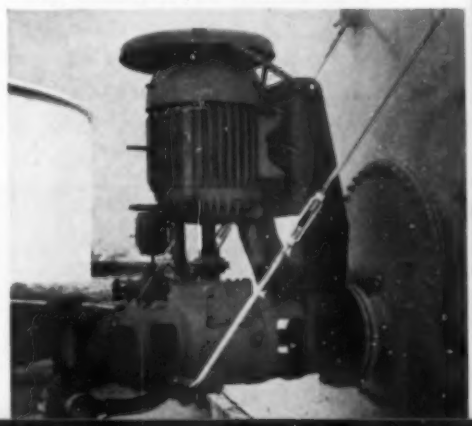

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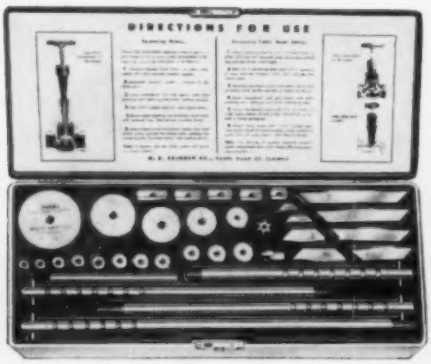

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Reseats flat and tapered-seat globe or angle valves —all bibbs and faucets— in place, quickly and accurately. The saving, over tearing out and renewing leaky valves and fixtures, is tremendous.

Cutters operating under screw feed, leave worn, scored seats glass-smooth, level, absolutely accurate and tight.

A guide pilot centers each cutter; a tapered cone centers each spindle. Perfect alignment is inevitable. Cutters guaranteed. Write for literature!

2" for ¼" to 2" valves and ¼" to ¾" bibbs
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3" for ¼" to 3" valves and ¼" to ¾" bibbs
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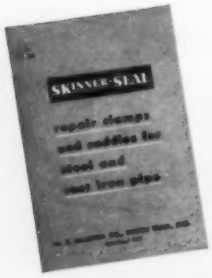

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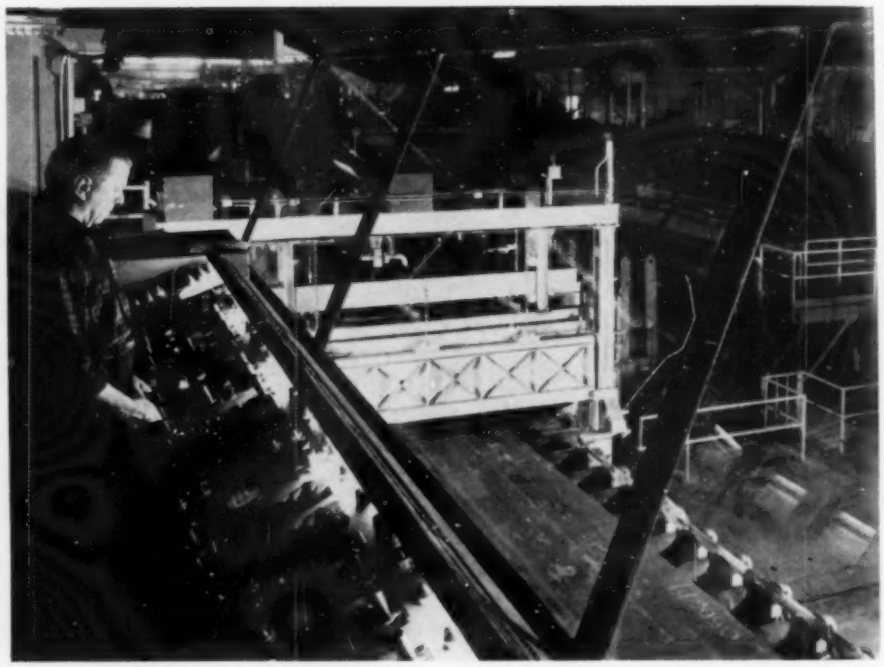

Steel Plate Heat Treating Line

Operator controls movement of steel plate as it leaves tempering furnace of a continuous plate-heat treating line recently installed at United States Steel's Homestead District Works. The treating line, which consists of hardening and tempering furnaces and water quench, treats plates up to 2-inches thick for use in several industries including petroleum. From tempering furnace it advances to water quench.

Fiberglas Appoints Welly Manager of Product Sales

Thomas J. Welly has been named manager of corrosion protection products sales of Owens-Corning Fiberglas Corp. He will handle pipe line wraps and reinforced plastic anti-corrosion products including pipes and tanks.

White Motor Company Promotes Wallace Assistant Chief Engineer

Robert C. Wallace has been named assistant chief engineer of White Division of White Motor Company. He formerly was director of engineering of the company's Diamond T Division.

Wallace will be in charge of the new model development. He has been with the company since 1947 when he was named vice president-engineering for Diamond T.

Mason-Neilen Appoints Three Representatives

Mason-Neilen, Division of Worthington Corporation, has appointed three new representatives expanding coverage in the southeastern states. Systems Service Corporation at Charlotte, N. C.; Ward K. Stallings Co., Atlanta, Ga., and Frank A. Thomas Company, Mobile, Ala., are the representatives. The Atlanta and Birmingham offices have been closed. L. M. Chester, formerly Mason-Neilen district manager at Birmingham, has joined the Stallings firm.

Crane Co. Elects Three New Directors

Crane Co. has named three new directors. P. Blair Lee, John D. Garrison and D. C. Fabiani, executive vice president, are new directors. Lee had been president of

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PIPELINE VENTS AND MARKERS

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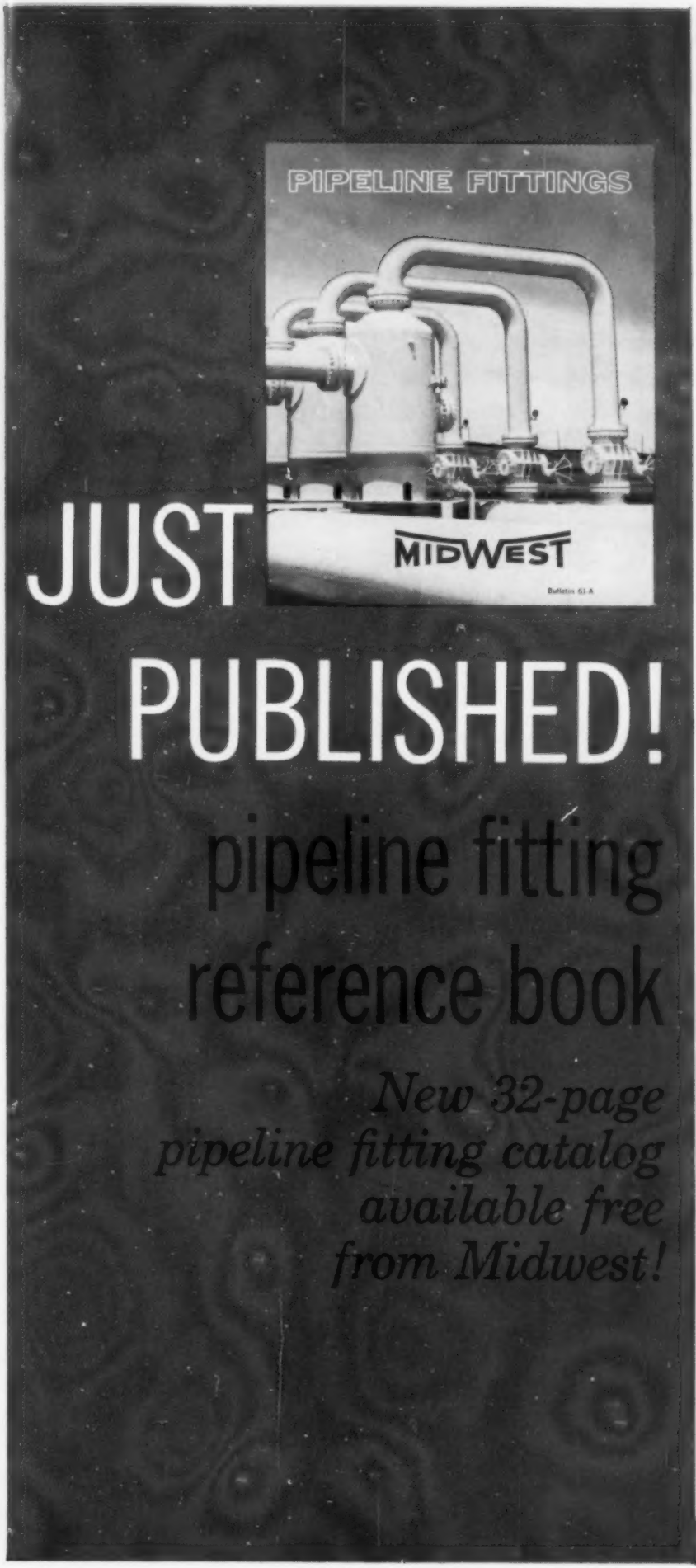

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Now in service at compressor and pumping stations of many gas and oil transmission companies . . . it has proved efficient and accurate the year around in all climates.

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Specializing in Measuring and Recording Instruments for 50 Years.

Western Saving Fund Society of Philadelphia. Garrison is a partner in the law firm of Lord, Day & Lord.

Howard Freyensee Becomes Bucyrus-Erie Sales Manager

Howard Freyensee has been appointed general products sales manager, and Robert P. Brooks succeeds him as large machine sales manager for Bucyrus-Erie Co.

Freyensee has been with the company since 1945, and in 1958 became sales development manager. Another company appointment is George F. Gilligan's transfer from Erie, Pa. to Evansville, Ind., as works manager.

W. J. McBrian

L. L. Morgan

Caterpillar Tractor Executives Promoted

Vice president W. J. McBrian has been named to succeed Gail E. Spain who had administrative responsibility for foreign marketing for Caterpillar Tractor Co. Spain and Henry H. Howard, vice presidents, retired June 1.

E. C. Chapman

McBrian also becomes president of Caterpillar Americas and Caterpillar of Delaware. Since 1956 he had been chairman and managing director of Caterpillar Tractor Co., Ltd. Lee L. Morgan replaces Howard as vice president in charge of engine division, and assumes administrative responsibility for Defense Products Department. E. C. Chapman, formerly assistant sales development manager, succeeds Morgan as manager of sales development. Morgan joined the company in 1946, and Chapman has been with Caterpillar since 1945.

Grove Valve & Regulator Co. Appoints Two Sales Engineers

Grove Valve and Regulator Company has named two sales engineers. Frank F. Ross has been appointed to the Pittsburgh office and I. M. Dearing, Jr., was named to the Lafayette office.

Ross had been with National Supply Company, and Dearing was affiliated with Oil Center Tool Co.

Perna Named Chief Engineer For Bennett Pump Division

Angelo J. Perna has been named chief engineer for John Wood Company's Bennett Pump Division. He will be in charge of product improvement and new product development.

Prior to joining Bennett, he had been at Kaydon Engineering.

Worthington Corp. Elects Ellenberger Vice President

Fred R. Ellenberger has been elected vice president, international operations, Worthington Corporation. He succeeds S. Riley Williams who retired.

Ellenberger has been with the company since 1938, and became assistant vice president—international operations in 1960.

Lynch Communications Names Chapman Application Engineer

John Chapman has been appointed application engineer in the marketing division of Lynch Communication Systems, Inc.

Chapman has been a sales engineer with Lenkurt Electric Co. and earlier had been with Automatic Electric Sales Corp.

Westinghouse Air Brake Co. Names James Vice President

Robb W. James has been appointed a vice president of Westinghouse Air Brake Company. Presently James is general manager of Union Switch & Signal—Division of Westinghouse. Formerly he was executive vice president of National Pneumatic Company and Holtzer-Cabot Electric Motor and Telephone Divisions in Boston, Mass.

General Electric's Gifford Appointed Committee Member

Richard P. Gifford, manager of engineering for General Electric Communication Products Division, was appointed a member of the joint technical committee of the Institute of Radio Engineers and Electronic Industries Association.

The committee evaluates technical and engineering information relating to the radio art. It advises government bodies, industry and professional groups.

Koehring Company Names Two New Distributors

Carroll & Edwards Co., Cincinnati, Ohio, has been appointed a distributor for southeastern Ohio by Koehring Division of Koehring Co. Harris Truck & Equipment Co., Trementon, Utah, has been named distributor for Koehring, Parsons and Koehring Co. of California Divisions. Harris also is a distributor for C. S. Johnson Co. products, a Division of Koehring.

BS&B Announces Three Mid-Continent Appointments

Thomas F. Casey, Jr., has been appointed account executive for the Mid-Continent Region, and William H. Moody

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Pipe Line Division

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ENGINEERS – SURVEYORS
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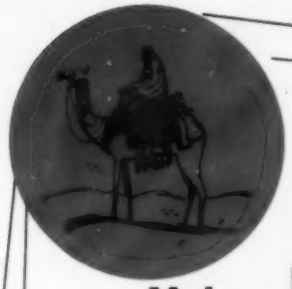


Proved Protection Against Pipe Corrosion Makes PLICOFLEX TAPE the Specified Choice On Major Pipe Line Projects

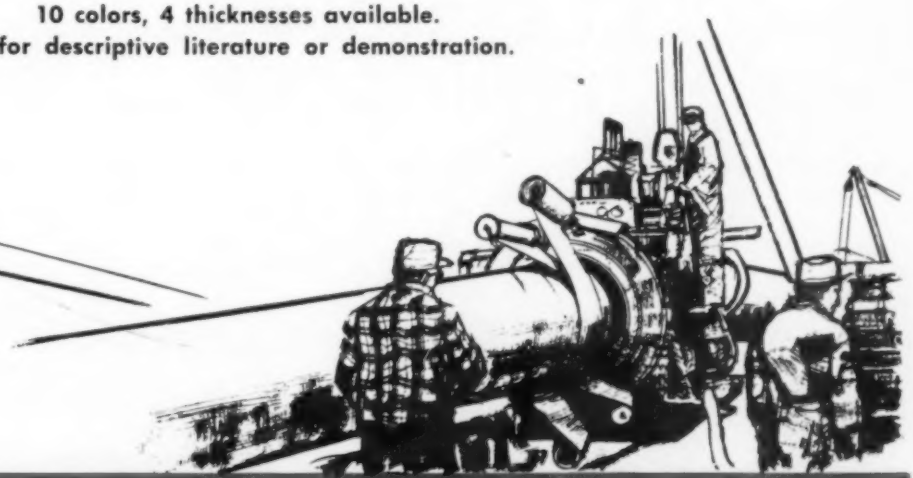
All Over the Free World

Major pipe line projects in Libya (100 miles of 30″ pipe), United States (80 miles of 30″ pipe), Chile, Tierra Del Fuego oil field (all crude and products lines in field), France (83 miles of 8″ pipe), Colombia (140 miles of 10″ pipe), and the Persian Gulf (6″, 8″ and 12″ pipe), that have used Plicoflex pipe line tape recently (Oct. 1960—Mar. 1961) are only some of the many examples of pipe lines where Plicoflex was the *specified* corrosion resistant material.

Plicoflex laminated butyl-vinyl tape used in combination with Plicoflex butyl base primer is moisture proof · non-conductive · impact resistant · bacteria proof · abrasion resistant · soil stress resistant · chemical resistant.

Application is simple . . . all you need do is give the pipe a good wire brushing, apply the primer at prevailing temperature and wrap and ditch the pipe.

10 colors, 4 thicknesses available.
Write for descriptive literature or demonstration.



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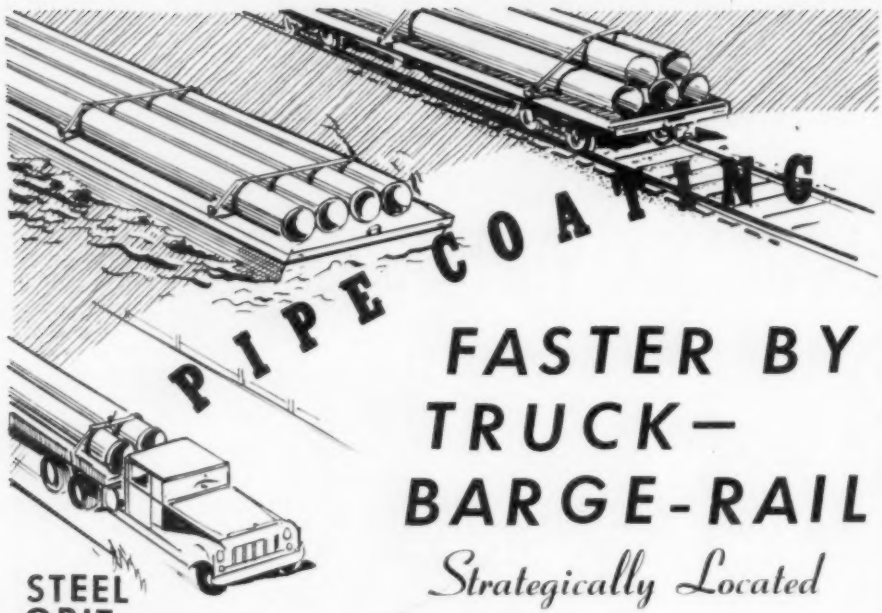

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Voss Valves are made to specification, machined from solid stock (not cast)—using best alloy steels; for corrosion condition—stainless steels, such as 410, 18-8 or non-ferrous alloys—monel, inconel, etc. Plates are machined (not stamped) and ground for precise close tolerance fit; are dimensionally stable . . . ductile . . . resist fracture, high temperatures and corrosion . . . withstand fatigue. Springs of heavy rectangular sections and large diameters add to dependability and safety.

- up to 40% more valve area
- minimum pressure loss
- higher efficiency
- less power consumption
- normal discharge temperature
- quiet, vibration-free
- utmost safety
- lower operating costs

For detailed proposal send name, bore, stroke and speed of machine.

J. H. H. VOSS VALVES REG. U.S. PAT. OFF.

J. H. H. VOSS Co., Inc.
785 East 144th Street,
New York 54, N. Y.

has been named resident manager of the Tulsa sales office for Black, Sivalls & Bryson, Inc. Also Edward W. Reif becomes regional sales manager for the Mid-Continent area.

Reif, who joined BS&B in 1942, was product sales manager for controls and specialty products. Casey has been with the company since 1946. Moody joined the company in 1952, and served as chief applications engineer and product supervisor for gas process equipment.

Brodie Appoints Bjornestad Southwest Division Manager

E. R. Bjornestad has been appointed southwest district manager for Ralph N. Brodie Company. He succeeds J. J. Kropp, Sr., who has retired.

E. R. Bjornestad

He will be responsible for administration and direction of Bi-Rotor meter, and control valve sales and service in Texas, Oklahoma, Louisiana, Arkansas and Tennessee. His headquarters will be in Dallas.

Walworth Company Appoints A. L. Barber Vice President

S. L. Barber has been named vice president of Walworth Company and president of its subsidiary, Southwest Fabricating & Welding Company, Inc.

Barber succeeds A. B. Judd as president of the subsidiary firm. Judd becomes chairman of the board. Barber formerly was executive vice president of Taylor Forge & Pipe Works, and is president of Uni-Flex Manufacturing & Engineering, Inc.

Midwestern Manufacturing Names Davis General Manager

D. K. Davis has been named general manager of Midwestern Manufacturing Company. Davis had been with Douglas Aircraft Company for 11 years.

T. J. Simpson Joins R. Mack Goble Company

T. J. Simpson has joined the R. Mack Goble Company, representative of Conoflow Corporation in Houston territory. Simpson's background is in the process industries in Texas Gulf Coast area.

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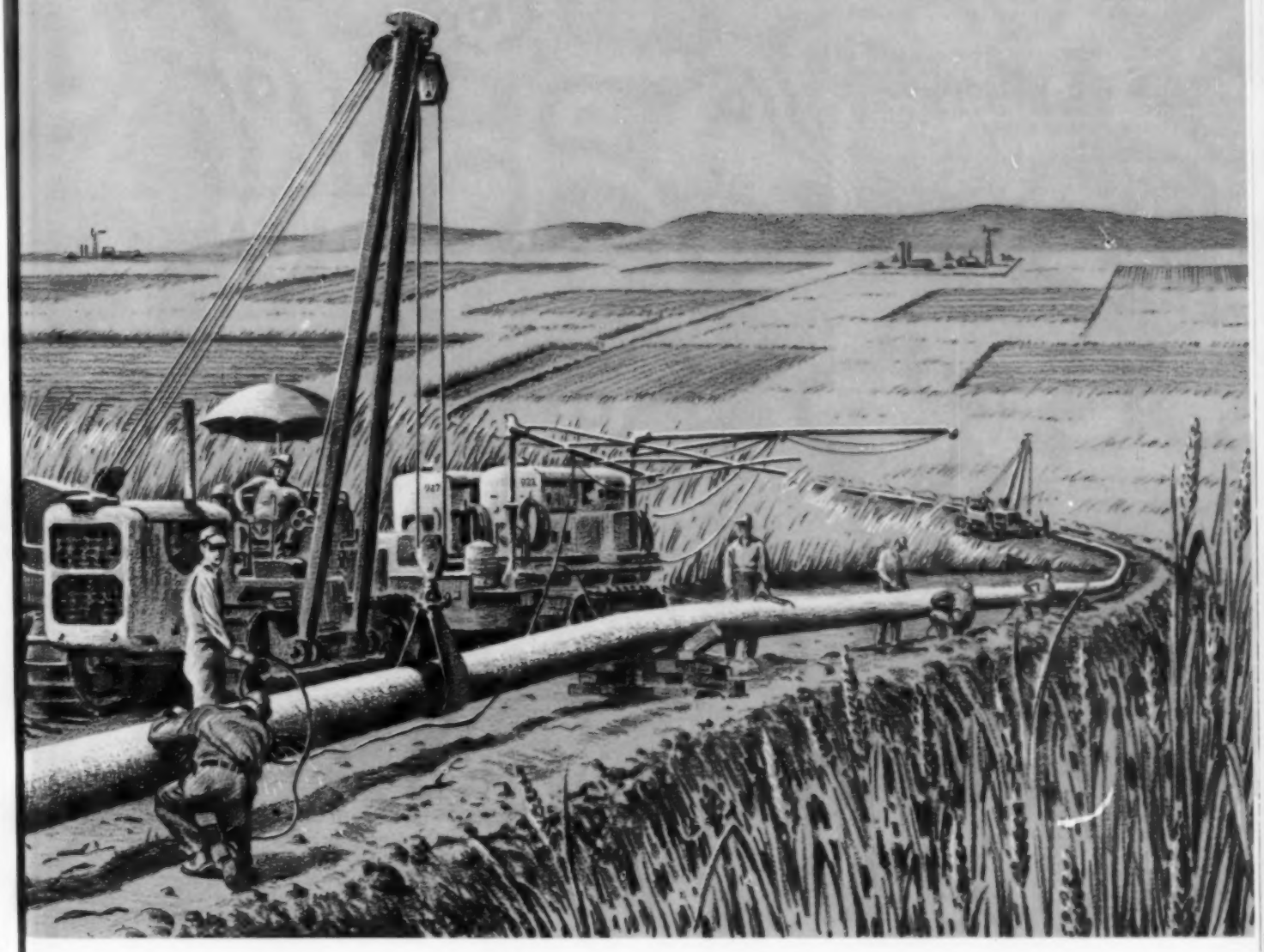
Beneath The Spring Wheat Lies an Even Richer Harvest



Hundreds of miles of pipelines gathering this "harvest" of il and gas in the Northern Great Plains are built with tupp Corporation *high-yield strength, lightwall steel line ipe.* And now even more pipeliners are specifying Stupp orporation *custom-manufactured* pipe—they know it means aster, easier and safer handling, improved bendability and eldability, and *major all-around economies* at highest indus- y standards. Sizes range from 6⅝ through 16 inches. New nger lengths (up to 64 feet) mean *up to 34 fewer field welds er mile.* Call, write or wire Stupp Corporation for a quota- on on *your* next job . . . wherever it is.

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MANUFACTURER OF CUSTOM STEEL LINE PIPE
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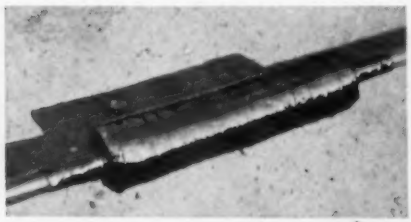
TAPECOAT® PROTECTION

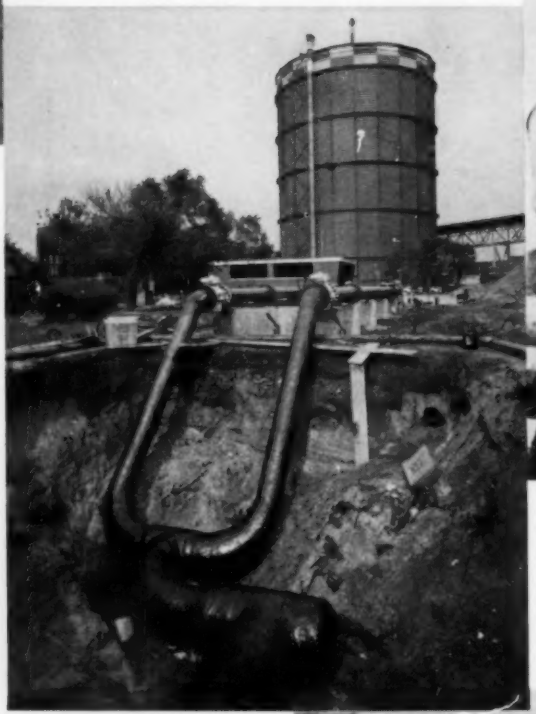
Works for You Anywhere!

NATURAL GAS lines at compressor and meter stations give years of maintenance-free service when protected by TAPECOAT, the coal tar coating in handy tape form.

GAS DISTRIBUTION lines of large diameter can readily be protected with TAPECOAT to withstand the abrasive and corrosive climate in underground service.



CABLE AND CABLE SPLICES in communications service are effectively and economically protected by TAPECOAT.



Lines in **OFF-SHORE DRILLING** operations need joint protection equivalent to the mill-wrapping on the pipe. TAPECOAT is most economical because it gives lasting protection in underwater service.

AIRPORT FUEL LINES need the quality joint protection assured by TAPECOAT. It is easy to apply by spiral or "cigarette" wrapping depending on the size of the pipe. No training needed.

STEEL MILL water lines in this new plant are joint-protected with TAPECOAT. TAPECOAT can be used to advantage to protect any steel surface in underground service, as proved since 1941.

UNDERGROUND GAS STORAGE facilities can be "buried and forgotten" when protected by TAPECOAT. Note protection of tanks, pipe and pipe joints.

Lines buried in cinders in **RAILROAD YARDS** need the sure protection provided by TAPECOAT. There's a size for every purpose from 2" to 24" in width.

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Originators of Coal Tar Coating in Tape Form

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Manufactured and Distributed in Canada by
The Tapecoat Company of Canada, Ltd.,
25 Haas Road, Rexdale, Ontario.

Ingersoll-Rand Company Names Eight Vice Presidents

Ingersoll-Rand has announced election of two executive vice presidents and six vice presidents. Edward J. Parish, board member and executive vice president, was named head of company's general line products in the United States and foreign countries.

Jacob J. Janzen and D. Wayne Hallstein were named executive vice presidents. The new vice presidents are Herbert Cresswell, David C. Garfield, John G. Lutz, Maxwell L. McCormack, E. Raymond Sheering and Joseph A. Wiendl. An operating committee consisting of Robert H. Johnson, chairman, Lester C. Hopton, president, and Parish, was announced to direct the engineering, manufacturing and sales policies of Ingersoll-Rand.

Robert B. Anderson Joins Dresser Industries, Inc. Board

Robert B. Anderson, former Secretary of the Treasury, has rejoined the board of directors of Dresser Industries, Inc. Prior to his role as Secretary of Treasury, he had been associated with several oil companies and served as president of the Texas Mid-Continent Oil & Gas Association. Recently he became affiliated with the Carl M. Loeb, Rhodes & Co.

R. B. Anderson

Electric Machinery Mfg. Company Names Mullenbach General Manager

Robert J. Mullenbach has been named general manager of the E-M-Control Division. This is a new position resulting from reorganization. He will be responsible for all activities of the new division including all engineering, manufacturing and sales.

Graver Tank Names Finnegan Manager of Product Planning

Joseph J. Finnegan has been named manager of the new Product Planning Department which recently was established by Graver Tank & Mfg. Co.

Finnegan had been with a Chicago-based investment firm before joining Graver Tank.

Centriline Corp. Appoints Stolzman Midwest Manager

Centriline Corporation has named Donald A. Stolzman midwest district manager and opened an office in Chicago. Stolzman had been with the Koppers Company.

Cooper-Bessemer Acquires Kline Manufacturing Co.

Cooper-Bessemer Corporation has acquired the Kline Manufacturing Company of Galena, Ohio. Kline's work, manufacturing hydraulic pumps and motors, will be continued as a wholly-owned subsidiary. No changes in management and personnel has been made.

Nordberg Mfg. Co. Appoints International Division Manager

Howard L. Phillips has been appointed International Division manager for Nordberg Mfg. Co. Tom Young was named an engine sales representative in the state of Louisiana. Phillips succeeds B. T. Eagerton, who has retired. He will handle all functions of the Export Sales Department and administration of overseas branches, foreign manufacture and license agreements. He has been with the company since 1947.

Young has had more than 30 years experience in diesel engine industry.

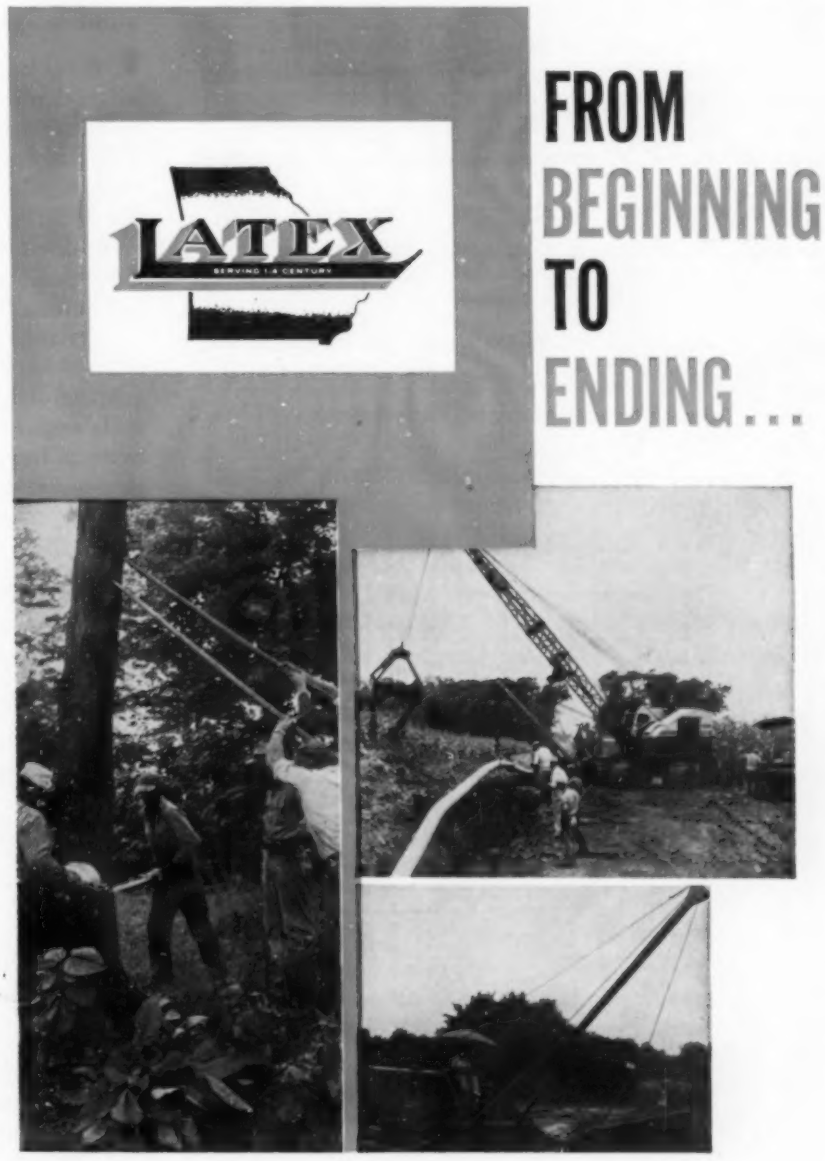
Union Switch & Signal Names Haley Product Manager

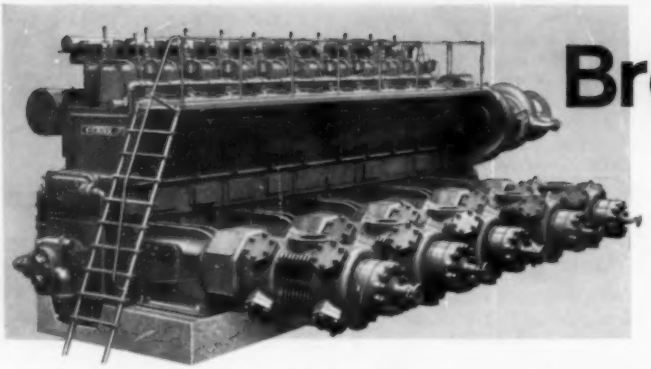
William F. Haley has been promoted to product manager systems of General Apparatus Department of Union Switch & Signal—Division of Westinghouse Air Brake Company. Haley had been southwestern district office manager in Houston. He will be responsible for systems marketing and engineering in the General Apparatus Department.

Haley joined Union Switch in 1952, and in 1959 was named southwestern district manager.

R. W. Lowell Named Manager Of Bristol Company Supply

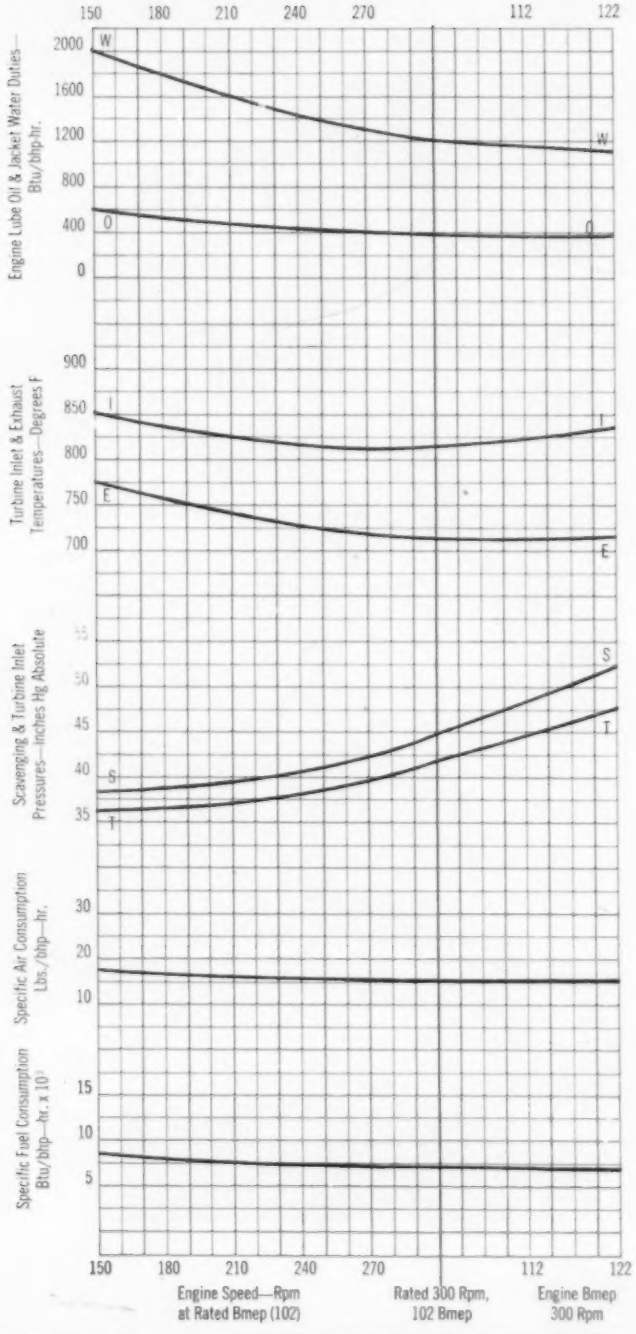
Robert W. Lowell has been appointed manager of The Bristol Company's Supply Department. He joined the company in 1954 and has been assigned as project engineer on telemetering equipment and electrical instruments. He will be headquartered in Waterbury, Conn.





Breakthrough in two cy variable speed, va

Automatic ignition timing plus automatic turbocharger control provide unrivaled speed, load and response characteristics.



Performance curve of Clark Model TLA turbocharged, 2-cycle, gas-engine-driven compressor. Unit features 17"x19" bore and stroke. Rated speed is 300 rpm. Rated bmep is 102 psi. Note the remarkable parallel between the fuel consumption and specific air consumption curves.

Q. What makes two cycle engines so well suited for variable-speed, variable-load applications?

A. It has long been traditional to consider two cycle engines as good prime movers for applications where power and speed are maintained close to 100% of rated load and speed. This may have been true a number of years ago when two cycle engines were single and twin horizontal designs. But the situation began to change with the introduction of vertical, multicylinder machines with direct fuel injection. Subsequent addition of constant pressure turbocharging and automatic ignition timing control have made two cycle performance equal or superior to four cycle engines in acceleration and in response to load or speed changes. Regardless of how fast the load or speed changes, the two cycle engine is able to adjust more rapidly because it fires twice as frequently. As a result the actual amount of load change between successive firings is cut in half, all other conditions being equal.

Q. Why has turbocharging caused such a vast improvement in two cycle engines?

A. The Clark system of constant pressure turbocharging permits variation of scavenging air flow with load to maintain relatively uniform air/fuel ratios over the complete operating range. This variable air supply plus maintenance of optimum ignition timing enables Clark engines to achieve excellent performance from substantial temporary overloads at rated speed down to the usually recommended 50% speed at constant torque.

Q. Why is constant pressure turbocharging so effective?

A. In general, all turbocharged engines are arranged to achieve best efficiency and fuel consumption at a particular design point—usually rated load. The Clark system of constant pressure turbocharging, however, is inherently capable of maintaining optimum efficiency not only at design point, but over an extremely broad operating range as well. The reason: *Clark turbocharging provides a flexible supply of combustion air that varies in direct proportion to load.* It does not depend on pulses of exhaust gas or on engine driven blowers, hence is free to provide the exact amount of air demanded by the engine. At light loads, there is neither a fall-off in performance nor any "lean out" problem arising from too much air. With increased loads, the turbocharger is able to pump increasingly more dense scavenging air into the power cylinders. There is no element in the

cycle compressor performance for variable load applications

system to impede or interfere with the performance of the turbocharger as it responds to the higher power requirements. Thus the fuel/air ratio remains constant through the entire operating range for best engine performance.

Q. Are there other important advantages of the Clark Constant Pressure Turbocharging system?

A. Yes. In addition to efficient combustion, the large amounts of available scavenging air have a cooling effect on the cylinder walls, cylinder heads and piston heads. Possibility of detonation is minimized, better lubrication is assured, and the temperatures of the exhaust gases are controlled as they enter the turbocharger. The cooling effect of the excess scavenging air is especially advantageous at high ambient temperatures. It lowers overall cooling duty and enables the Clark intercoolers to provide adequate scavenging air cooling. There is no need to resort to evaporative cooling of air or other special means of preventing detonation and cylinder wear.

Q. How does Clark achieve such good low speed lugging characteristics?

A. With Clark turbocharged, two cycle engines, compressor capacity can be most easily and efficiently varied by adjusting speed while maintaining at or near rated load torque. *The engine-driven compressor is then operating at rated load all the time, at which condition it functions most efficiently.* The exceptional low speed lugging characteristics are due primarily to frequent power impulses that reduce cyclic speed variation. At low speeds, cyclic speed variation is always accentuated because flywheel inertia is reduced in proportion to the square of speed reduction, and power impulses become less frequent with respect to time. Thus the two cycle engine has a great advantage because each cylinder fires every revolution.

Q. How do Clark two-cycle engines perform under overload conditions?

A. A glance at the chart showing actual test data taken from a Clark turbocharged Model TLA gas-engine-driven compressor demonstrates graphically that the fuel consumption curve is remarkably flat over a wide range. When operating as high as 20% overload under emergency conditions, Clark engines actually burn *less* fuel per bhp than at rated load. Even more important is the manner in which the specific air and specific fuel consumption curves parallel each other perfectly over the entire range. This illustrates the inherent advantage of Clark "true" turbocharging system. Once the engine is started and the turbine is self-sustaining, the turbocharger adjusts itself freely and almost instantaneously to the demands of the engine.

Q. How does ignition timing control improve operating performance?

A. There are two conditions in which ignition timing control is used with the Clark system: At startup and at reduced speeds. During the starting cycle, the timing control automatically adjusts the ignition to increase the flow of heat to the turbocharger. This shortens startup time and substantially reduces consumption of starting air.

At reduced speeds (i.e. from 50% to 80% rated speed), the ignition is automatically regulated to maintain optimum ignition timing consistent with the rate of pressure rise in the cylinder with respect to time. Thus the peak pressure is reached at or near top dead center and expansion of the burned gases takes place most effectively with less tendency to detonation.

Q. What is the net effect of combining turbocharging with two-cycle engines?

A. The user enjoys all the advantages of a two-cycle engine —simplicity, fewer moving parts, greater dependability— plus the advantage of turbocharging—more power in less space, better fuel economy, greater operating flexibility. Clark two-cycle gas-engine-driven compressors are very conservatively rated. Lower bmep eliminates the ignition difficulties and fouling tendencies common in higher rated machines. There are no large exhaust or intake valves to warp, pit or burn. Two-cycle design keeps continuous downward pressure on the power pistons, thereby eliminating oil "pumping." There is no piston ring blowby, the cause of sludging and crankcase oil dilution. The two-cycle engine is less sensitive to detonation under high ambient temperatures. Thus Clark design reduces costly maintenance and assures more profitable "uptime."

Q. In what type of application is Clark capacity variation with speed useful?

A. Pipeline gas transmission where there are few units in a station. Process applications employing gas engine drivers. Gas distribution boosters where the compressors are located near sales outlets. Manufactured gas compressors. Field gathering compressors where few units can be economically employed and wide variation in gas supply is expected.

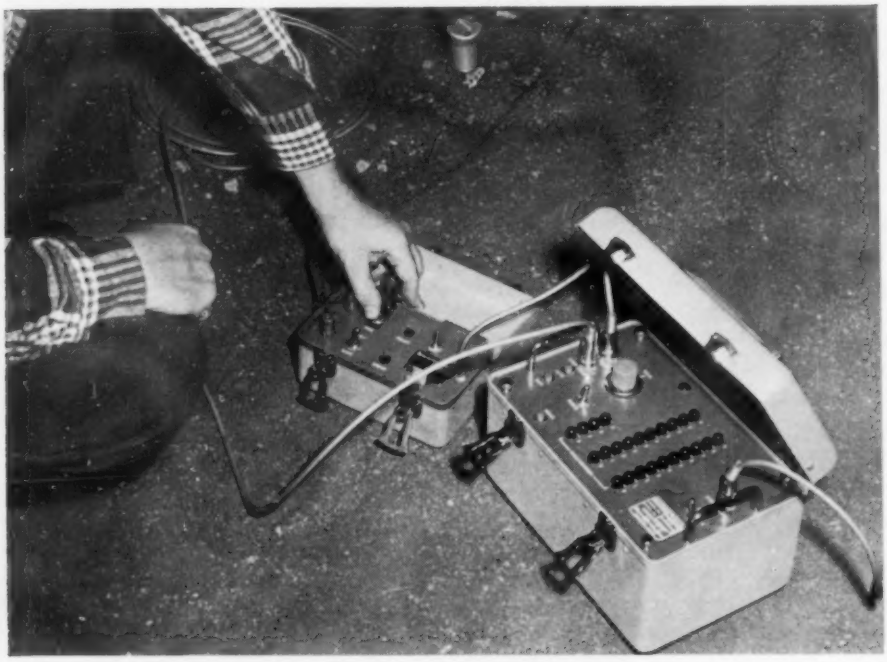
For more details on how Clark variable-speed, variable-load performance can help you, contact your nearest Clark office or write to:

CLARK BROS. CO., OLEAN, N. Y.

CLARK
ENGINES · COMPRESSORS
GAS TURBINES
DRESSER INDUSTRIES INC.
OIL · GAS · CHEMICAL
ELECTRONIC · INDUSTRIAL

For more data on advertised products, use Readers' Service Cards, last page.

What's New in EQUIPMENT

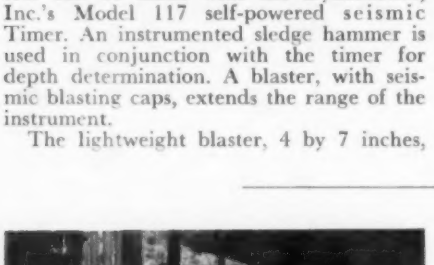


Timing Device

Bedrock depth determination up to 100 feet can be made with the DynaMetric, Inc.'s Model 117 self-powered seismic Timer. An instrumented sledge hammer is used in conjunction with the timer for depth determination. A blaster, with seismic blasting caps, extends the range of the instrument.

The lightweight blaster, 4 by 7 inches, is a battery operated capacitor discharge type, good for thousands of shots without battery replacement. It has a built-in circuit tester, ready light and positive, three-switch safety feature. It is available in two-cap capacity, for seismic work, or in multi-cap capacity for large shots.

For more data, circle **No. E1** on Readers' Service Card, last page this issue.



Epoxy Coating

A new epoxy coating for internal coating of pipe lines has been developed by Bradco Plastics, Inc. The PlastXcoat epoxy coating is a self-priming material and can be applied on days of high humidity—even during rain.

The coating is available in 20 colors and it also can be used on materials such as wood, plastic, concrete, brick, glass, aluminum and hard to paint transites.

For more data, circle **No. E2 on** Readers' Service Card, last page this issue.

Pipewelders Special

The pipewelders' special, a combination welding-cutting-heating outfit designed especially for the pipe welding industry, has been announced by Smith Welding Equipment Corporation.

Features of this special welding outfit include: welding tips slip-in and nut hand tightens, hex also is provided on nut, tip rotates 360 degrees; short design with rugged copper section and precision flame stability, and recommended pipe size embossed on each of five tips. Torch body has extruded "easy grip" handle with brass forged butt; ball type needle valves, and is available in two lengths for operating preference. Cutting assembly slips into torch body, nut hand tightens; lever flips for unrestricted access to nut; 75 or 90 degree head available. Cutting tip slips in, head nut hand-tightens. Outfit complete for $74.50.

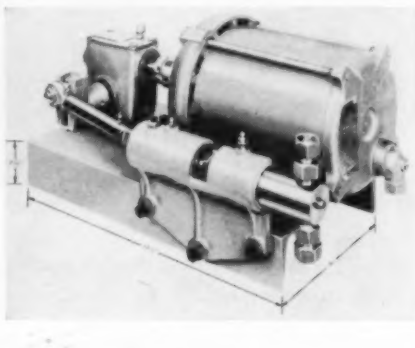
For more data, circle **No. E3** on Readers' Service Card, last page this issue.

Dragline-Clamshell

A diesel-electric dragline-clamshell has been added to the Bucyrus-Erie Company line of heavy-duty crawler excavators. The Model 210-B has boom lengths of 100, 120 and 140 feet and can handle buckets up to 10 cubic yards.

Elimination of friction clutches for all cylinder functions is a key feature of the product. Hoist and drag or holding and closing motions are regulated by a static type control of independent electric eddy current clutches, which are liquid cooled by a radiator system. Three sets of crawlers are available—standard, intermediate and long-wide for soft ground conditions.

For more data, circle **No. E4** on Readers' Service Card, last page this issue.



Vari-Flow Pump

ARCCO Instrument Company, Inc., has developed a new vari-flow pump to supply liquid to its gravitometers from lines operating under high pressure where no differential is available. It is designed to work under extremely high pipe line pressure. The pump is powered by an explosion proof motor and is easily adjusted.

Two models are offered from zero to several thousand cc flow per minute. Model GSP-HP1, a single cylinder pump for pressure up to 1,000 psi, has an output volume of 0 to 2,000 cc per minute. It's equipped with a ⅓-horsepower motor and constructed of stainless steel. Model GSP-HP2 is two-cylinder pump for pressures to 1,000 psi with an output up to 4,000 cc per minute. It also has a ⅓-horsepower motor and comes in stainless steel.

For more data, circle **No. E5** on Readers' Service Card, last page this issue.

Sphere/Pig Detector

A pipe line sphere and pig detector has been developed by F. H. Maloney Company. The Mark IV Sphere Here is a pressure-balanced unit which gives accurate detection in any gas or liquid pipe line. It is designed to be installed in any position on the line and can detect with equal response from either direction.

It is available with any or all of four accessories, micro switch, visual indicator, five digit counter, pneumatic pilot valve. The unit is especially suited for use on high speed, displacement type meter provers. It can be installed at launching

or receiving traps or at intermediate points. For installation, a 1¾-inch hole is drilled in the line and pre-scarfed base is welded on. Base plate is made of carbon steel, but is available in other materials.

(This item supplements F. H. Maloney Co. data on Pages 249-252 of the Pipe Line Catalog.)

For more data, circle **No. E6** on Readers' Service Card, last page this issue.

Angle Blade

A high strength steel angle blade for two models of the Michigan line of rubber tired tractor dozers has been announced by Construction Machinery Division of Clark Equipment Company.

Designed for use of models 180 and 280 tractors, the blade may be angled 25 degrees to right or left. The blade has its own C frame for mounting to the dozer. On the 180 model, maximum cutting depth with blade in straight position is 1 foot, 10 inches and in angled position it is 2 feet, 6 inches.

For more data, circle **No. E7** on Readers' Service Card, last page this issue.

Alert System

An automatic logging electronic reporting and telemetering system (ALERT) which keeps a constant vigil on pipe line operations, has been introduced by RCA Industrial Computer Systems Department.

The system uses RCA 130 industrial data transmission link to relay performance information and control instructions to and from stations. It provides up-to-the-second reports on pressures, station failures or power breakdowns. The central control station consists of control panel, display panel showing the system, an alarm printer, test data logger, automatic typewriter and paper tape equipment. A wide variety of transmission media can be used with the RCA 130 equipment—vhf, telephone or telegraph lines, submarine cables or microwave.

For more data, circle **No. E8** on Readers' Service Card, last page this issue.

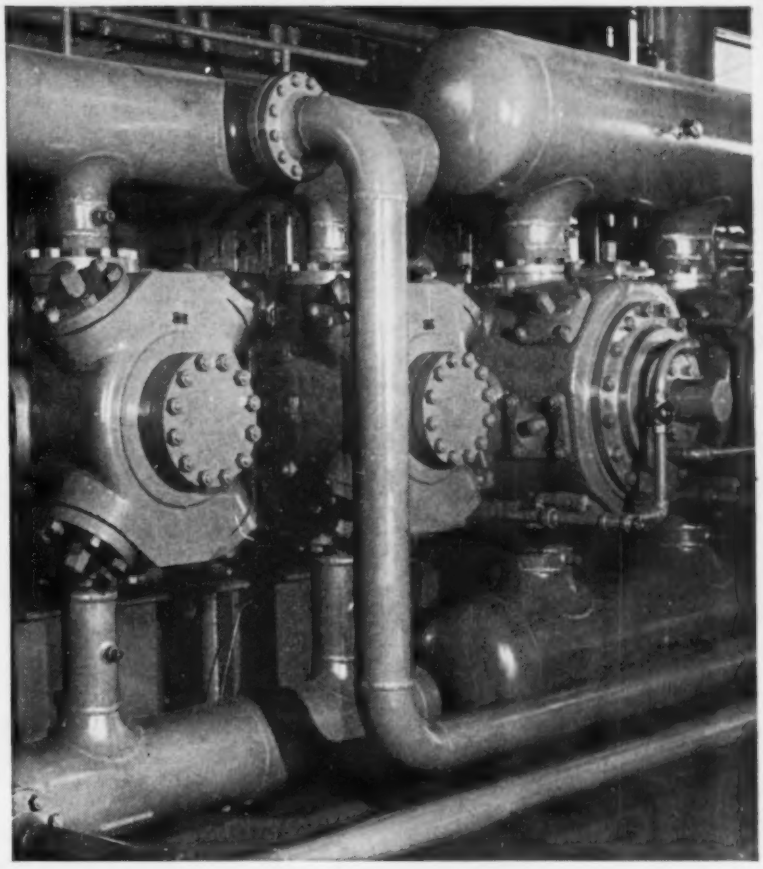
Transparent Epoxy

A transparent epoxy adhesive called "reading clear" has been introduced by Lazzara Company. The high strength epoxy material becomes transparent upon curing. It is designed for bonding glass to glass; metal to glass; metals to non-metals, fiberglass, ceramics, plexiglass, porcelain and pyro ceramics.

It can be used on repairing strain gages, printed circuits; securing headers, transformer insulators, terminals, nameplates, etc.

For more data, circle **No. E9** on Readers' Service Card, last page this issue.

PACKAGED
COMPRESSOR PIPING...



another example of

BONNEY SWEEPOLETS®

for sophisticated piping systems

Designed to eliminate all notch effects, the Bonney Sweepolet provides optimum stress distribution for critical piping systems such as the compressor bottles shown above on Worthington SLHC-10 gas engine angle compressors rated at 950 BHP each. These units were fabricated by Worthington-Lockett using Bonney Sweepolets for branch construction. Specify and use Bonney Sweepolets in your critical piping systems.

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for all services

BONNEY FORGE AND TOOL WORKS
ALLENTOWN, PENNSYLVANIA

Paywelder rigs "wade" track-deep to make 150 joints per day!

Through "hip-boot" mud and water conditions, International® Pay welder rigs, on 24-inch tracks, claw their sure way. Even in this adverse going, the stringer-bead and hot-pass crews make 150 joints per 10-hour day—getting 6,000 feet of line daily.

This is a Panama Williams Corporation looping job in Louisiana for Trunk Line Gas Co. Panama Williams also uses another Pay welder team on a second looping job. Without the mud to fight, the second pair does up to 7,500 feet daily, making 165 welds!

The International Pay welder is a factory-engineered, factory-built, high-output 325-amp machine. It's powered and carried by the 6-cylinder TD-15 crawler tractor, equipped to produce 120 intermittent hp. This compact, go-anywhere power package carries two Lincoln dual welders (4 welders), with four welding leads—is V-belt-driven from front pto. Pay welder comes standard equipped, fore and aft, with rugged steel extension platforms. Mount your clamp-actuating compressor on the front platform, and drive it from front pto extension that's provided. And carry extra pipe clamps and supplies on the rear platform. No separate compressor engine—no "supply wagon"—needed!

Self-contained and self-propelled, the spread-speeding Pay welder has the ground-hugging stability of 74-inch gauge tracks to operate on all terrain. For maximum flotation-traction use 24-inch track shoes.

Put a Pay welder to the toughest test you can find. Then compare the cost-cutting ability, the earning capacity of this factory-built, field-proved welding unit. See what it means to generate the current, power the compressor, and transport supplies with one mobile, one-man-operated unit. Let your International Construction Equipment Distributor demonstrate.

In "soupy" mud, two International TD-15 Pay welder units keep the crews producing—keep the job going—on the Panama Williams Corporation line-looping job near Rayville, Louisiana. "I can set the welder controls and run three or four hours without ever changing them," states the operator of the lead Pay welder. All controls of the Lincoln dual welders are easy to reach and regulate—all indicator dials are easy to read!

Through a "frog-pond," the Pay welder navigates—"pouring" out the 325-amp current to keep four welders busy. Precision-type metal-to-metal cartridge-type seals protect the Dura-Rollers on TD-15 tracks from water and abrasives. These track rollers with king-size reservoirs give 1,000-hr lubrication intervals!

p swamp

—for Panama Williams Corporation, Houston, Texas

International® Construction Equipment

International Harvester Co.,
180 North Michigan Ave., Chicago 1, Illinois
A COMPLETE POWER PACKAGE

Lowering-in Belt

A new 10-foot by 24-inch neoprene-protected lowering-in belt swing sling has been introduced by Colorado Fuel and Iron Corporation. The belt is protected on edges by neoprene caps and provides maximum protection for coated and concrete covered pipe lines during transfer and laying operations. Lifting capacity of belt is 250,000 pounds.

For more data, circle **No. E10** on Readers' Service Card, last page this issue.

Tank Thermometer

A valve type tank thermometer that can provide faster, more accurate readings has been introduced by W. H. Curtin and Company. It employs a bucket valve which opens as the thermometer is lowered into the tank, allowing oil to flush through cup case. When desired level is reached and thermometer is withdrawn, bucket valve closes, retaining a sample from that level.

Oil flushing through the cup as unit is lowered keeps mercury column at or near temperature of the oil, making faster readings.

For more data, circle **No. E11** on Readers' Service Card, last page this issue.

GET MORE SPEED
...MORE DEPENDABILITY

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VERTICAL PIPE BENDER

- Fastest bending machine on any spread. C-R-C's reversing clutch gives equal speeds forward and reverse.
- No flattening or egging of pipe. For smooth, wrinkle-free bends on the strongest pipe made . . . the C-R-C Bender is your best buy.
- Cable operated for dependable performance, economical maintenance.
- The C-R-C Model "B" Bender is under eight feet wide on tires or tracks.

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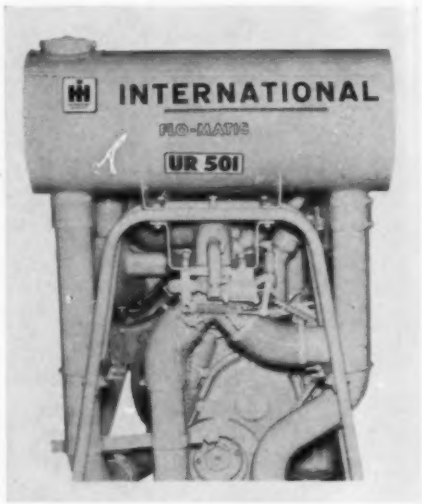
In Canada: Canadian Equipment Sales & Service Co., Ltd., 7310 99th St., Edmonton, Alberta, Canada



Cooling System

A cooling system for non-radiator cooled engines—Flo Matic—is available for 14 International Harvester Company engines. Flo-Matic maintains a high-volume, high-velocity, coolant flow, producing uniform engine temperatures.

Seven of the engines applicable are six-cylinder carbureted units—UB-220, UC-221, UG-262, UB-264, UR-372, UR-450 and UR-501. Three are V-8 carbureted—UV-401, UV-461, and UV-549 and four are six-cylinder diesels—UD-236, UD-282, UD-817 and UDT-817.

For more data, circle **No. E12** on Readers' Service Card, last page this issue.

Power Crane

Latest addition to Unit Crane & Shovel Corp. line of power cranes and excavators is Model 27-C, a one-yard shovel which is easily converted to dragline, trenchoe, clamshell, liftcrane and magnet crane front ends. A compact swing-circle gear assembly with upper works mounted on a large diameter, double-live ring of steel balls

And the finest quality steel tubing today carries the Ⓢ and Ⓨ symbols of Yawata Steel Tube Co., Ltd. (Formerly Nippon Tokushu Steel Tube Co., Ltd. with Ⓢ NTK mark), an important subsidiary of the giant Yawata Iron & Steel Co., Ltd. Our main products in Pipe & Tubing (seamless or welded) include:

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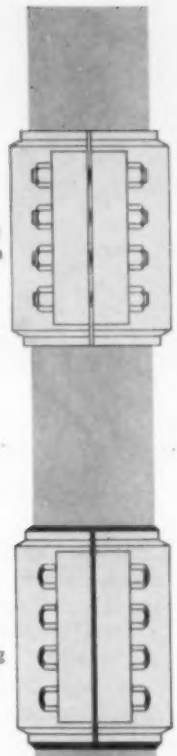
FAST, SAFE PIPELINE REPAIRS WITH NEW SMITH SPLIT-COUPLING



The Smith Split-Coupling can be used as coupling, repair clamp or split sleeve.
Easy installation—Place halves around pipe. Tighten side bolts.
Permits welding while pumping.
Available in standard pipe sizes.
Extra lengths and special dimensions on application.

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Research
Responsibility
Results

Aerotec's 16 years experience in dry gas scrubbing

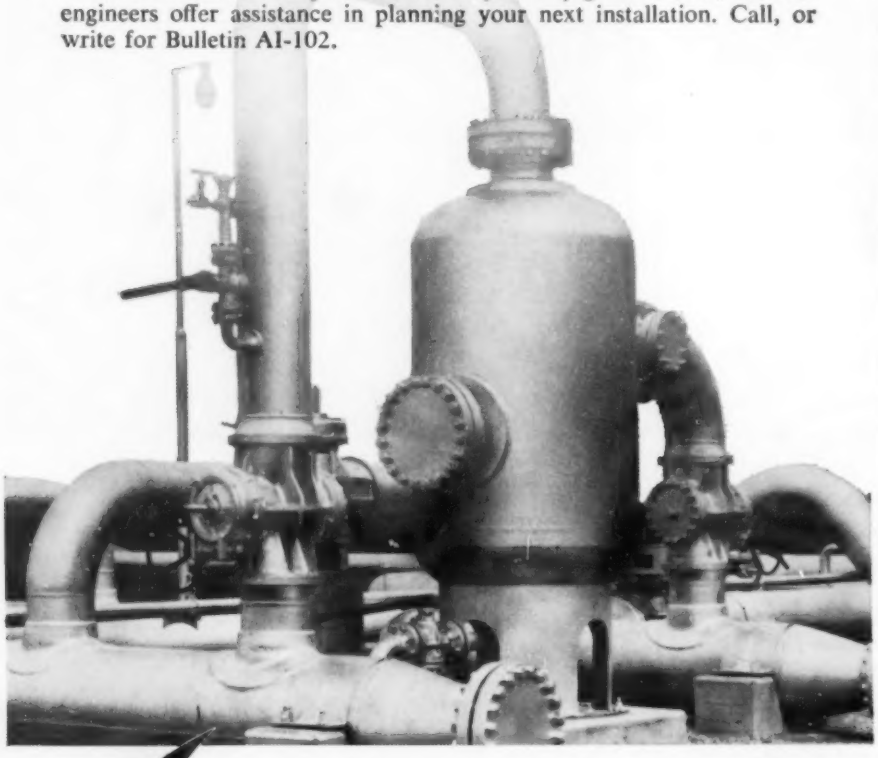
. . . your assurance of top performance

The centrifugal method of dry gas scrubbing, developed by Aerotec more than 16 years ago, is still the most advanced method known. The Aerotec scrubber is equally efficient in removing liquids as well as solids from the gas stream. Unlike conventional fluid types, there is no troublesome oil carryover.

Development of the centrifugal gas scrubber was undertaken by Aerotec in cooperation with the natural gas industry. It is significant that these scrubbers have found wide acceptance on almost every major pipeline, both at transmission-line compressor stations and city gates. Over 1200 major installations assure you the ultimate in trouble-free performance.

The design and dimensions of the Aerotec tubular elements are critical to top efficiency, deviations will impair performance. Effectiveness of the Aerotec dry scrubber has been proved by 16 years' experience and substantiated by the AGA Tests Reports NFX-12, a claim no other centrifugal type scrubber can make.

To assure maximum performance of your dry gas scrubber, Aerotec engineers offer assistance in planning your next installation. Call, or write for Bulletin AI-102.



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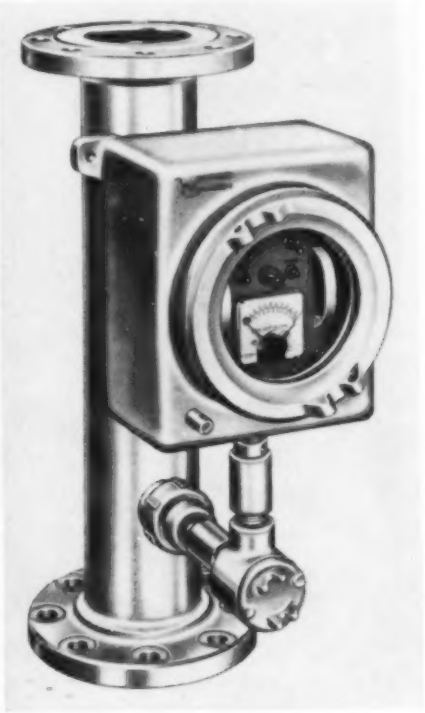
running in hardened races is one of the unit's features. This produces a fast swing, and there's practically no day-to-day lubrication or maintenance required.

Swingers run in a bath of oil which is kept cool by a set of copper coils connected directly to the radiator cooling system. Thermostatic control holds temperature below the point where clutch lining life is normally affected by heat.

For more data, circle **No. E13** on Readers' Service Card, last page this issue.



Bridge Type Monitor

A precision capacitance bridge type monitor designed specifically for LACT systems has been developed by United Engineers. The Model TDM-X dielectric monitor will indicate continuously the percentage of BS&W in the crude oil flowing through the measuring probe.

The control unit is housed in an explosion-proof housing with a removable glass window for easy viewing of the control panel. The complete control assembly is calibrated directly in percentage of BS&W. The monitor features a completely transistorized circuit, replaceable plug-in modules, high and low limit control, fail safe voltage regulation, push button test set and zero elevation suppression.

(This item supplements United Engineers, Inc. data on page 488 of the Pipe Line Catalog, Third Revision.)

For more data, circle **No. E14** on Readers' Service Card, last page this issue.

Swing Check Valve

Designed to offer all advantages of a check valve and flow control, the full-flow swing check valve has been announced by Magnetrol, Inc. The Model FCV offers a valve disc magnetically coupled to the switch mechanism, which features mercury to mercury switch contacts. The unit is designed to remotely signal flow or no-flow through the valve and/or provide an interlock safety control in start-up or shutdown. It also can reliably indicate position

PANTEX valve actuators cost less and perform more than any other in the field!

Pantex Valve Actuators provide complete automatic control of the flow of liquids and gases in pipe lines.

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LIQUID LEVEL and FLOW CONTROL

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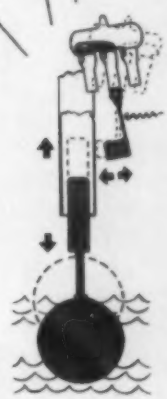
3 unfailing elements safeguard critical liquid level or flow

A **sleeve**, raised and lowered within a nonmagnetic tube as liquid level or flow rates change, attracts or releases a permanent magnet attached to a **mercury switch** outside the tube. That's all there is to it.



MAGNETROL

These three simple elements—the heart of Magnetrol—outmode all bellows, packing glands, and electrodes. Unfailing actuation, as dependable as the pull of a magnet, eliminates all wearing parts and maintenance; nothing to go wrong.

Magnetrols operate indefinitely to protect the critical level or flow of almost **any** liquid, at virtually **any** temperature or pressure. They are so simple that a change in material is usually all that is needed to adapt standard units to any specific application. "Special" Magnetrols are rare.

Magnetrols are available for controlling liquid level changes from ¼" to 150' and more with single or multi-stage switching; flow switches to signal start, stop or insufficient flow within fractions of gpm rates.

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☐ Liquid Level Controls ☐ Flow Controls

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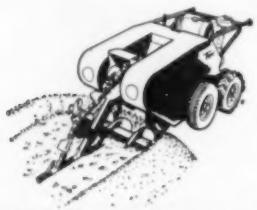

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- Reversible Four Wheel Drive
- Retractable Transport Wheels
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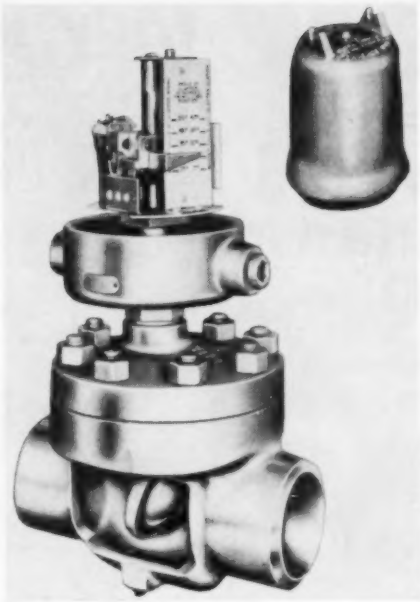


of valve disc at any point from full closed to full open.

The valve is fully field adjustable. Its indexed and adjustable electric switching element provides signal at any preset position of the valve disc.

For more data, circle **No. E15** on Readers' Service Card, last page this issue.

Aerial Markers

A new line of air markers for pipe lines has been developed by Handley Industries, Inc. Markers have holders for numeral signs on which each digit occupies a rectangle of 12x16 inches. Posts and signs are made of rubber-resin compound and signs are secured by means of nylon rivets in a non-corrosive frame of extruded and welded aluminum. Markers are supplied with 7-foot posts.

For more data, circle **No. E16** on Readers' Service Card, last page this issue.

Bearing Grease

A high/low temperature ball and roller bearing grease filtered to 10 or 45 microns has been announced by Bearing Inspection, Inc. Grease is supplied in ½-ounce syringes, with needles, as a standard package unit, and will meet or exceed most "Mil Spec" requirements.

Its primary application is regreasing of permanently sealed bearings. It also can be used in solving greasing problems in miniature and other precision bearings.

For more data, circle **No. E17** on Readers' Service Card, last page this issue.

Level Control Instruments

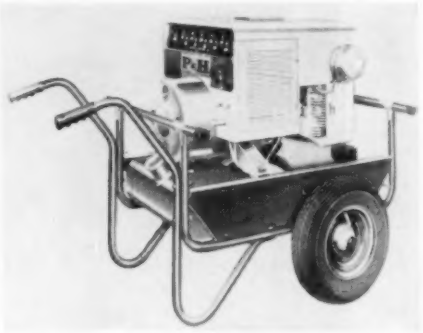
A line of level control instruments, including electric and pneumatic transmitters that also provide indication and perform on-off functions, is announced by Brooks Instrument Company, Inc.

Instruments can be supplied in special materials for toxic, corrosive and high pressure, to 40,000 psi services. They are available with buoyant and displacer floats for liquid or interface level or specific gravity application.

For more data, circle **No. E18** on Readers' Service Card, last page this issue.

Welder-Power Plant

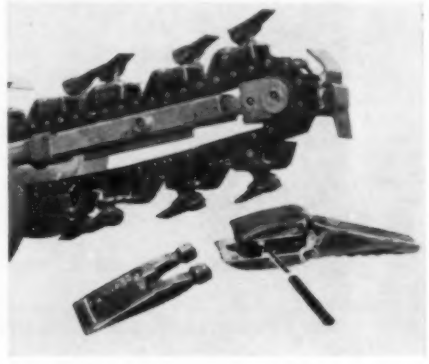
An engine driven DC welder which also serves as an AC power plant has been developed by Harnischfeger Corporation. Rated at 200 amps, 50 percent duty cycle, the machine delivers 3½-KW, 120 volts



AC, 60 cycle current for lighting and electric tools.

Power is supplied by a two-cylinder, four-cycle air-cooled gasoline engine of 12.8 horsepower at 2,600 rpm, complete with a 12-volt electric starter.

For more data, circle **No. E19** on Readers' Service Card, last page this issue.



Trencher Tooth

A replaceable, reversible trencher tooth designed for light to medium duty trenching machines, has been introduced by Petersen Engineering Company, Inc.

Designated #35, the forged, heat-treated alloy steel tooth is secured to the PENGO T35 adapter shank by means of a rubber lock. This permits free fit between tooth and shank, yet the compressed rubber locks the tooth securely.

For more data, circle **No. E20** on Readers' Service Card, last page this issue.

NOW! Avoid costly installation delays . . .
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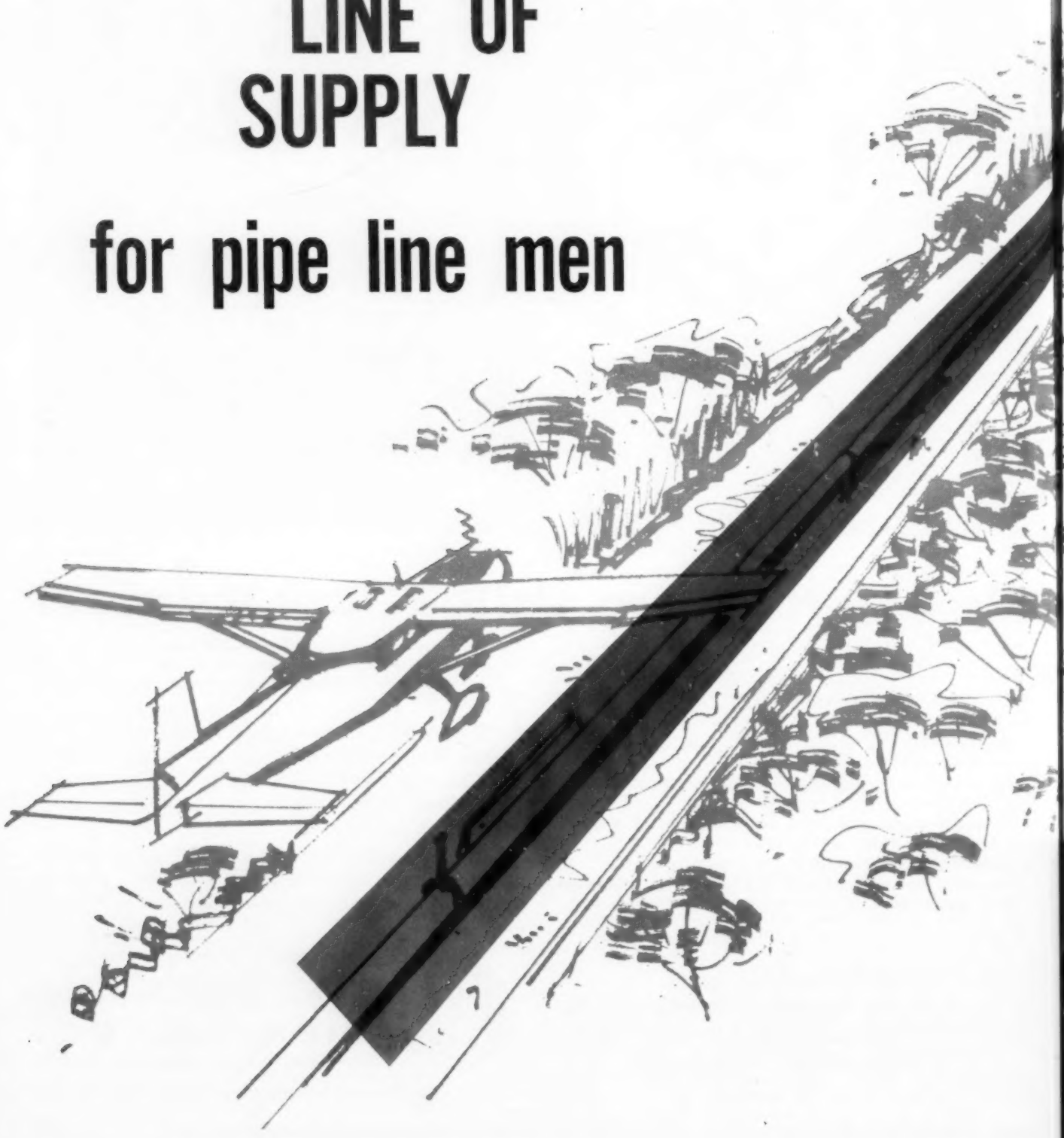

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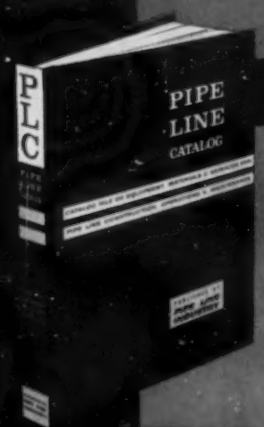

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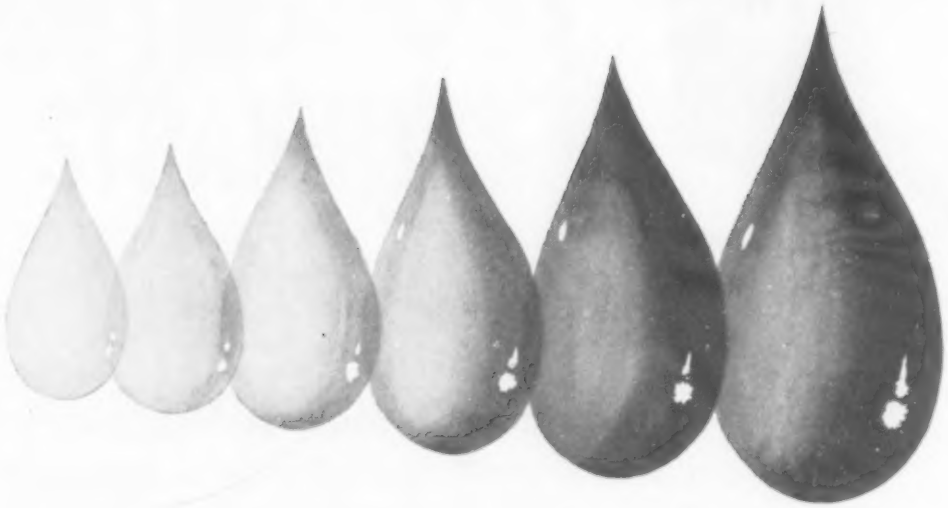

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New Equipment Literature

For more data on New Equipment or copies of Catalogs and Literature reviewed in this issue, use the Reader Service postcards just inside the back cover and facing the Advertisers' Index. Simply circle code numbers of items desired—sign and mail card.

Ball Valve

A 6-page folder on "How to Buy a Ball Valve" has been issued by Hydromatics, Inc. It enumerates 8 important valve features that a buyer should look for in a ball valve. It includes a cutaway drawing of a series 701 top entry 150# ASA flanged Flo-Ball valve and an exploded view showing one moving part, seats and seal.

One table lists parts and materials of construction, while another includes prices and model numbers of each size from one to 8-inch.

To get a copy, circle **No. E21** on Readers' Service Card, last page this issue.

Pipe Line Fittings

A 32-page bulletin on pipe line fittings has been issued by Midwest Piping Company Incorporated. The highly illustrated and detailed publication gives information on types of elbows, branches, headers and tees, saddles, fittings, venturi type reducers and flanges. It includes tables on gas and oil piping with allowable working pressures.

To get a copy, circle **No. E22** on Readers' Service Card, last page this issue.

Engine Exhaust Snubbers

A bulletin on a series of engine exhaust snubbers for reduction of noise of engines, blowers, compressors and vents has been released by Burgess-Manning Company.

The series is completely redeveloped and engineered. Each of the series is designed for a particular level of noise suppression They will be marketed as BMA- first line; BMB- standard and BMC- compact.

To get a copy, circle **No. E23** on Readers' Service Card, last page this issue.

Two-Cycle Engine

Clark Bros. Co. has released a bulletin which discusses two-cycle gas engines with emphasis on performance characteristics in variable-speed and variable-load applications.

Constant pressure turbocharging and ignition timing control and advantages of each in two-cycle engine performance are covered.

To get a copy, circle **No. E24** on Readers' Service Card, last page this issue.

Tractor Equipment

Features and applications of Allis-Chalmers Manufacturing Company crawler and wheel utility tractor equipment are now available in an illustrated three-fold specification sheet.

Information on the new HD-3 and H-3 crawler tractors is included.

To get a copy, circle **No. E25** on Readers' Service Card, last page this issue.

Plastic Products

Trans-Plastics Corporation, a new technological organization marketing a complete line of pipe, pipe fittings, sheet and engineered fabrications made of corrosion-resistant PVC, polyethylene and ABS, has published a brochure to introduce the company products.

This is to be part of an 80-page, 2-color engineering manual.

To get a copy, circle **No. E26** on Readers' Service Card, last page this issue.

Temperature Transmitter

An 8-page specification outline features information on Minneapolis-Honeywell Regulator Company's new pneumatic temperature transmitter which uses a filled thermal system and transmits standard 3-15 psi signal which varies in proportion to changes in the measure temperature.

Complete specifications on gas and mercury filled systems available with transmitter are included in the sheet.

To get a copy, circle **No. E27** on Readers' Service Card, last page this issue.

How to control pipeline corrosion for $0.0011 per barrel

As a pipeline operator, you know what internal corrosion of the line can mean in reduced lifetime, decreased throughput, frequent scraper runs, premature replacement of filters, meters and valves – as well as product contamination.

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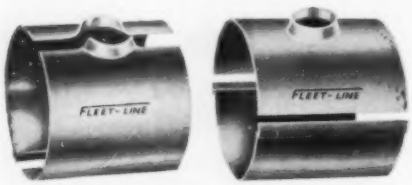

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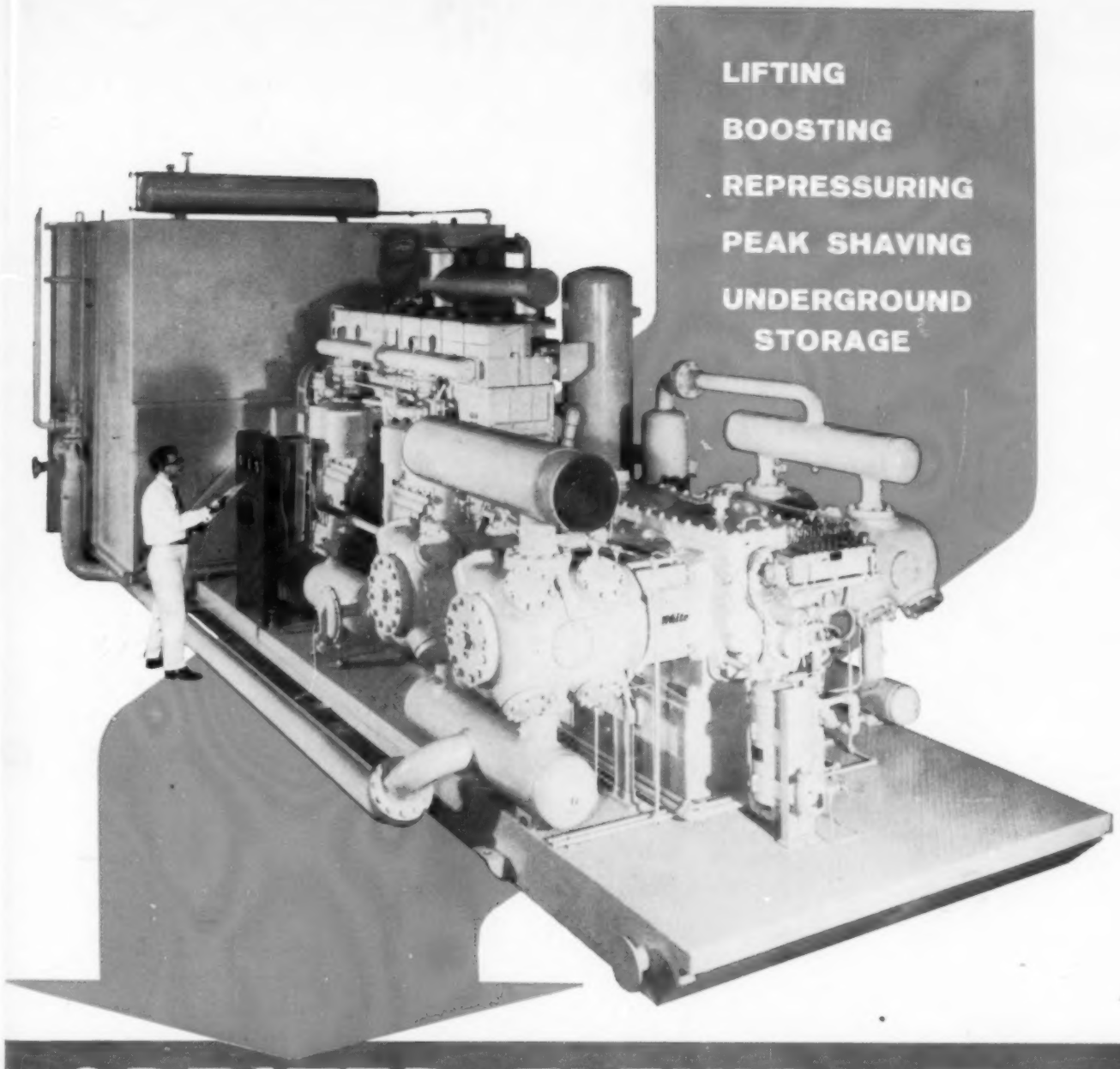

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